UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/650,113	12/30/2009	Nereida Maria Menendez	51017-84536	6718

21888 7590 05/04/2017
THOMPSON COBURN LLP
ONE US BANK PLAZA
SUITE 3500
ST LOUIS, MO 63101

EXAMINER	
VIG, NARESH	

ART UNIT	PAPER NUMBER
3622	

NOTIFICATION DATE	DELIVERY MODE
05/04/2017	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

IPDOCKET@THOMPSONCOBURN.COM

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte NEREIDA MARIA MENENDEZ,
PAULA S. WILLIAMS,
and MICHAEL J. MANIS

Appeal 2015–002128
Application 12/650,113
Technology Center 3600

Before ANTON W. FETTING, MICHAEL W. KIM, and
NINA L. MEDLOCK, *Administrative Patent Judges.*

FETTING, *Administrative Patent Judge.*

DECISION ON APPEAL

STATEMENT OF THE CASE[1]

Appellants seek review under 35 U.S.C. § 134 of a final rejection of claims 1–9, 11–13, 15–25, 27–32, 34–36, 38–80, 82–84, 90, 92–94, 100, and

[1] Our decision will make reference to the Appellants' Appeal Brief ("App. Br.," filed September 2, 2014) and Reply Brief ("Reply Br.," filed December 1, 2014), and Supplemental Brief (Suppl. Br.", filed September 23, 2016), and the Examiner's Answer ("Ans.," mailed October 1, 2014), and Final Action ("Final Act.," mailed August 7, 2013).

104–114, the only claims pending in the application on appeal. We have jurisdiction over the appeal pursuant to 35 U.S.C. § 6(b).

The Appellants invented a way of completing a rental agreement for an item or service, such as a vehicle rental service. Specification 1:23–24.

An understanding of the invention can be derived from a reading of exemplary claim 1, which is reproduced below (bracketed matter and some paragraphing added).

> 1. A method for creating online and storing within a server system a completed electronic rental contract for engaging a rental vehicle from a rental car company's fleet to thereby authorize a user to pick up a rental vehicle without the user visiting a rental counter, the method comprising:
>
> [1] receiving data
>
> from a computer through a website during a visit by a user of the computer to the website,
>
> the data being representative of a user's future rental of a rental vehicle;
>
> [2] determining whether the user has a defined pre-existing customer relationship with the rental car company;
>
> and
>
> [3] performing the following steps
>
> even if the user is determined not to have the defined pre- existing customer relationship:
>
> [4] communicating an electronic rental proposal
>
> to the computer through the website for display to the user,
>
> the electronic rental proposal being for a rental transaction that is at least partially based on the received data for the future rental;

[5] receiving an electronic acceptance of the electronic rental proposal

from the user through the computer and through the website;

[6] creating the completed electronic rental contract for the rental transaction

in response to the received electronic acceptance,

the completed electronic rental contract resulting in the user being authorized to pick up a rental vehicle in accordance with the completed electronic rental contract

without the user visiting a rental counter;

and

[7] storing the completed electronic rental contract within the server system;

and

[8] wherein the data receiving step, the determining step, the performing step, the communicating step, the electronic acceptance receiving step, and the completed electronic rental contract creating step are performed by the server system executing software logic

during a single visit by the user of the computer to the website.

The Examiner relies upon the following prior art:

Information on Hertz Corporation, archived web pages printed through www.archive.org (1997–2000) (Hertz).

Avis Rent A Car – Rates and Reservations, http://www.avis.com/rates_and_reservations/ (last visited March 03, 2000) (Avis).

Hertz Announces New, Elite Levels for #1 Club Gold Members in the US, 11 July 2000, PR Newswire Association, Inc. (Hertz Gold).

In addition, the following references are newly cited:

Burch, Rental Car Companies Check Drivers' Records, Sun Sentinel, http://articles.sunsentinel.com/19930812/business/9301290359_1_cardriversmotorvehicles, August 12, 1993 (Burch).

Gallian, Assigning Driver's License Numbers, Mathematics Magazine, pp. 13–22, v. 64, n. 1, February 1991 (Gallian).

Claims 1–9, 11–13, 15–25, 27–32, 34–36, 38–80, 82–84, 90, 92–94, 100, and 104–114 stand rejected under 35 U.S.C. § 101 as directed to non–statutory subject matter.

Claims 1–9, 11–13, 15–25, 27–32, 34–36, 38–80, 82–84, 90, 92–94, 100, and 104–114 stand rejected under 35 U.S.C. § 112, second paragraph, as failing to particularly point out and distinctly claim the invention.

Claims 1–9, 11–13, 15–25, 27–32, 34–36, 38–80, 82–84, 90, 92–94, 100, and 104–114 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Hertz, Avis, and Hertz Gold.

ISSUES

The issues of statutory subject matter turn primarily on whether the claims do more than provide conceptual advice on how to rent a car. The issues of definiteness turn primarily on whether one of ordinary skill in the art would understand the metes and bounds of the claims. The issues of obviousness turn primarily on whether it was predictable for a customer to self-perform data entry, instead of going to a customer service counter for such entry.

FACTS PERTINENT TO THE ISSUES

The following enumerated Findings of Fact (FF) are believed to be supported by a preponderance of the evidence.

Facts Related to the Prior Art

Hertz

01. Hertz is a web site for Hertz, the car rental company, which provides the contents of the legal requirements for its agreements and provides screens for customers to enter rental reservations. Hertz 1–61.

02. Hertz describes its system as allowing a customer to make, modify, or cancel a reservation after checking rates. Hertz 27.

03. Hertz describes the use of a customer profile for entering data into a reservation. Hertz 17.

04. Hertz portrays radio button selection of entry by customers with existing profiles and general customers. Hertz 36.

05. Hertz describes an offer for a rental vehicle for value containing the material terms of the agreement, and requesting acceptance by the customer. Hertz 44.

06. Hertz shows separate screens for initially requesting dates and locations (Hertz 18) and for auto selection and pricing (Hertz 24) and for additional promotions. Hertz 26.

07. Hertz describes using the master agreement data for filling in a reservation. Hertz 27.

Avis

08. Avis describes entry and storage of a vehicle rental reservation. Avis 1–13.

Hertz Gold

09. Hertz Gold describes offering members an automatic invitation to move up to #1 Club Gold after completing four rentals. Hertz Gold 1.

10. "In 1972, Hertz became the first car rental company to recognize the strategic value of maintaining a customer profile database, with the introduction of Hertz #1 Club. The service created a data file for each customer, by maintaining driver's license information, home address, car class information and credit card information for instant recall. For Hertz' customers; #1 Club helped reduce time spent making reservations and sped the process when renting a car." Hertz Gold 1.

11. "After implementing #1 Club service, Hertz recognized the additional customer benefit to not only keeping an active profile on customers, but also allow[ing] customers to bypass the counter altogether, with the keys and completed rental agreement ready and waiting for them." Hertz Gold 2.

Burch

12. Burch describes how rental car companies are checking driver's records from their licenses. Burch 1.

13. Burch describes that the driving record check is performed online in less than a minute, so as not to delay the rental transaction. Burch 1.

Gallian

14. Gallian describes how driver license numbers are assigned. Gallian 13:Title.

15. Gallian describes how driver license numbers are encoded for possible detection of forgery or errors. Gallian 13:Introduction.

ANALYSIS

This is one of three applications before us with similar claims to a car rental system and method. The other two applications are Serial Nos. 12/650,040 and 09/698,502. The claims in all three applications generally recite performing an online car rental reservation that results in a rental contract. The claims in all three applications also recite doing so in a single session, without a customer having to visit a customer service counter and without requiring a pre-existing relationship or master rental agreement between the customer and the car rental company.

Claims 1–9, 11–13, 15–25, 27–32, 34–36, 38–80, 82–84, 90, 92–94, 100 and 104–114 rejected under 35 U.S.C. § 101 as directed to non–statutory subject matter

The Supreme Court

> set forth a framework for distinguishing patents that claim laws of nature, natural phenomena, and abstract ideas from those that claim patent-eligible applications of those concepts. First, [ ] determine whether the claims at issue are

> directed to one of those patent-ineligible concepts. . . . If so, we then ask, "[w]hat else is there in the claims before us? . . . To answer that question, [ ] consider the elements of each claim both individually and "as an ordered combination" to determine whether the additional elements "transform the nature of the claim" into a patent-eligible application. [The Court] described step two of this analysis as a search for an "'inventive concept'"—i.e., an element or combination of elements that is "sufficient to ensure that the patent in practice amounts to significantly more than a patent upon the [ineligible concept] itself."

Alice Corp., Pty. Ltd. v CLS Bank Int'l, 134 S. Ct. 2347, 2355 (2014) (citing *Mayo Collaborative Services v. Prometheus Laboratories, Inc.*, 132 S. Ct. 1289 (2012)).

To perform this test, we must first determine whether the claims at issue are directed to a patent-ineligible concept.

Although the Court in *Alice* made a direct finding as to what the claims were directed to, we find that this case's claims themselves and the Specification provide enough information to inform one as to what they are directed to.

The preamble to claim 1 recites that it is a method of creating and storing an electronic rental contract for a rental vehicle. The steps in claim 1 result in creating an electronic rental contract for (??) a user's future rental of a rental vehicle. We do not discern any functional language in claim 1, for example, any verb that would only have been relevant to the realm of vehicle reservations. The Specification at 1:23 recites that the invention relates to completing and storing an electronic rental agreement. Thus, all this evidence shows that claim 1 is directed to completing and storing an electronic rental agreement for (??) a user's future rental of a rental vehicle.

Further, although the words "electronic" and "rental" are used, again, we do not discern that removing the "electronic" and "rental" terminology appreciably affects the functional language of independent claim 1. The "electronic" limitations, such as "computer" and "website," are generic, and the "rental" limitations are merely descriptive, and do not affect how any of the steps are performed. For example, the "receiving . . ." step would function in the same way, whether the data created are "a user's future rental of a rental vehicle," as recited, or some other form of data. Additionally, we discern that, after removing "rental" limitations, a "user's future rental of a rental vehicle" is merely previously gathered data. We find that all contracts, at some level, must be based on previously gathered data. Accordingly, we find that independent claim 1 is directed to entering into an agreement or contract..

It follows from prior Supreme Court cases, and *Bilski* in particular, that the claims at issue here are directed to an abstract idea. Like the risk hedging in *Bilski*, we find that the concept of entering into a contract (based on previously gathered information) is a fundamental business practice long prevalent in our system of commerce. We find also that the creation and use of contracts is a building block of our legal system. Thus, entering into a contract, like hedging, is an "abstract idea" beyond the scope of §101. *See Alice Corp. Pty. Ltd.*, 134 S. Ct. at 2356.

As in *Alice Corp. Pty. Ltd.*, we need not labor to delimit the precise contours of the "abstract ideas" category in this case. It is enough to recognize that there is no meaningful distinction in the level of abstraction between the concept of risk hedging in *Bilski* and the concept of entering into a contract at issue here. Both are squarely within the realm of "abstract ideas" as the Court has used that term. *See Alice Corp. Pty. Ltd.*, 134 S. Ct. at 2357. We conclude that the claims at issue are directed to a patent-ineligible concept.

The introduction of a computer into the claims does not alter the analysis at *Mayo* step two.

> [T]he mere recitation of a generic computer cannot transform a patent-ineligible abstract idea into a patent-eligible invention. Stating an abstract idea "while adding the words 'apply it'" is not enough for patent eligibility. Nor is limiting the use of an abstract idea "'to a particular technological environment.'" Stating an abstract idea while adding the words "apply it with a computer" simply combines those two steps, with the same deficient result. Thus, if a patent's recitation of a computer amounts to a mere instruction to "implement[t]" an abstract idea "on . . . a computer," that addition cannot impart patent eligibility. This conclusion accords with the preemption concern that undergirds our §101 jurisprudence. Given the ubiquity of computers, wholly generic computer implementation is not generally the sort of "additional feature[e]" that provides any "practical assurance that the process is more than a drafting effort designed to monopolize the [abstract idea] itself."

Alice Corp. Pty. Ltd., 134 S. Ct. at 2358 (citations omitted). "[T]he relevant question is whether the claims here do more than simply instruct the practitioner to implement the abstract idea . . . on a generic computer." *Id.* at 2359. They do not.

Taking the claim elements separately, the function performed by the computer at each step of the process is purely conventional. Using a computer to accept and store data, and make simple "yes" or "no" determinations, to create a digital file amounts to electronic data query and retrieval—one of the most basic functions of a computer. All of these computer functions are well-understood, routine, conventional activities previously known to the industry. In short, each step does no more than require a generic computer to perform generic computer functions.

Considered as an ordered combination, the computer components of Appellants' method add nothing that is not already present when the steps are considered separately. Viewed as a whole, Appellants' method claims simply recite the concept of entering into a contract as performed by a generic computer. The method claims do not, for example, purport to improve the functioning of the computer itself. Nor do they effect an improvement in any other technology or technical field. Instead, the claims at issue amount to nothing significantly more than an instruction to apply the abstract idea of entering into a contract using some unspecified, generic computer. Under our precedents, that is not "'enough' to transform an abstract idea into a patent-eligible invention." *See Alice Corp. Pty. Ltd.*, 134 S. Ct. at 2360.

As to system claim 24, it is

> no different from the method claims in substance. The method claims recite the abstract idea implemented on a generic computer; the system claims recite a handful of generic computer components configured to implement the same idea. This Court has long "warn[ed] . . . against" interpreting § 101"in ways that make patent eligibility 'depend simply on the draftsman's art.'

Id. at 2360.

The dependent claims recite conventional data entry operations and user interface features or recite the automotive rental context features, which add nothing to overcome the abstract nature of the claims.

We are not persuaded by Appellants' argument that claim 1 is directed toward a particular machine under the "machine-or-transformation" test, because claim 1 recites a server system that is specially configured with software logic to perform recited steps of the method. Reply Br. 4. *Alice Corp.* explicitly responded to such an argument. Appellants' argument, by its own terms, admits that a general purpose computer is programmed to perform the steps of the abstract process. Accordingly, Appellants' method steps are no more than instructing the general purpose computer to perform the method steps by expressing the idea in a language the general purpose computer understands. Absent implementation details in claim 1 itself, we are unpersuaded that the computer process is any less abstract than the process itself.

We are not persuaded by Appellants' argument that

> claim 1 does not merely recite a "generic computer" in combination with an abstract idea. Independent claim 1 recites not only that "the data receiving step, the determining step, the performing step, the communicating step, the electronic acceptance receiving step, and the completed electronic rental contract creating step are performed by the server system executing software logic" but further recites that the server system performs these steps "during a single visit by the user of the computer to the website"; thus defining a method tied to a non-generic computer design.

Reply Br. 5. Appellants essentially argue that only part of the abstract idea is computer implemented. *Alice Corp.* informs that computer implementation *per se* does not turn an abstract process into a concrete process, and that this is also generally true for any combination where part of the underlying process is not computer implemented. We are unpersuaded that independent claim 1 is any different.

We are not persuaded by Appellants' argument that

> [i]n a dramatic improvement on this inefficiency, claim 1 defines a server system that functions better than the cited art

> by removing the technical feature in the cited art which conditioned the ability to conduct a rental counter bypass rental transaction on the user providing proof a pre-existing customer relationship.

Reply Br. 6. Conditioning a process on some criterion is not a technical step; it is conceptual advice to restrict the conditions in which to perform a process. In the instant case, the criterion is a convention that is not required to rent a car; it merely provides marketing opportunities that one might choose to forgo. FF 6, 11. Appellants have not identified any information, provided at a customer service counter that could not have been entered over a computer instead. Going contrary to a convention is a voluntary choice, and not a technical hurdle.

We are not persuaded by Appellants' argument that

> that there are myriads of machine-based methods falling outside the scope of claim 1 which are capable of generating an electronic rental contract authorizing a user to pick up a rental vehicle without the user visiting a rental counter. . . . Given that the abstract idea can be performed outside the scope of claim 1, claim 1 by definition does not pre-empt the abstract idea identified by the Examiner.

Reply Br. 6. We disagree. That the claims do not preempt all forms of the abstraction, or may be limited to the abstract idea in the car rental setting, without visiting a customer service counter, does not make them any less abstract. *See OIP Technologies, Inc. v. Amazon.com, Inc.*, 788 F.3d 1359, 1360–1361 (2015).

We are not persuaded by Appellants' argument that the Examiner cites no evidence that the steps performed were conventional as of the filing date. Suppl. Br. 3. The steps recite using a computer to accept and store data, and make simple "yes" or "no" determinations, to create a digital file which amounts to electronic data query and retrieval– one of the most basic functions of a computer.[2] To the extent Appellants argue the context and mental interpretation attached to the data labels, these are of no patentable significance, because they only exist in the mind of the beholder. *See In re Bernhart*, 417 F.2d 1395 (CCPA 1969).

We are not persuaded by Appellants' argument that the claims recite performing steps in a single visit, and even if there is no pre-existing relationship between the customer and the car rental company, and that the Examiner has failed to give this limitation due weight in considering what the claims are "directed to." Suppl. Br. 4. Whether the steps are performed in a single or plural set of visits is a matter of convention and tactical design, not technical capacity, and, thus, is subsumed within "entering into a contract." Even on a computer, merging two sets of programming steps into a single step is no more than merging two sets of textual computer code. Bypassing a customer service counter, in the absence of a pre-existing relationship between the customer and the car rental company, is, again, conceptual advice.

We are not persuaded by Appellants' argument that efficiency is improved by merging the two code streams. Suppl. Br. 5. This is no more than conventional computer operation in serially combining program instructions, and we are unpersuaded that it adds anything substantive to "entering into a contract" or amounts to "significantly more."

We are not persuaded by Appellants' argument that the claims do not preempt all ways of performing creating a contract. Suppl. Br. 7. That the

---

[2] IBM and Sperry Rand mainframe computers did as much in the 1960's.

claims do not preempt all forms of the abstraction, or may be limited to the abstract idea in the e-commerce setting, does not make them any less abstract. *See OIP Technologies, Inc. v. Amazon.com, Inc.*, 788 F.3d at 1360–1361.

We are not persuaded by Appellants' argument that the claims allow for improvements realized by the invention. Suppl. Br. 10. Adapting any conceptual advice does as much. Following the advice, which would have been known to one of ordinary skill at the time of the invention, that "haste makes waste" allows for improvement realized by avoiding the hazards of waste. This is not a case of such advice being applied to, for example, something as specifically and concretely rooted in computer technology as synchronizing lip animations, created by computer technology, that introduces asynchronous behavior to begin with. *McRO, Inc. v. Bandai Namco Games America, Inc.*, 837 F.3d 1299 (Fed. Cir. 2017). The instant claims do no more than advise one to avoid a customer service counter, which is not computer-specific behavior.

We are not persuaded by Appellants' argument that

> there is no evidence in the record that the pre-Internet world provided for the creation of electronic rental contracts that permitted counter bypass without leveraging a pre-existing MRA, much less doing so during a pre-Internet world analog to a single website visit.

Suppl. Br. 12. The claims do no more than the electronic equivalent of converting a reservation into a contract, which has been the foundation of the automobile rental industry since its inception.[3] FF 10–11. Although it is

---

[3] This has been a past practice of the automotive rental market since the 1960's.

true that before computers, a rental agent had to transcribe from the reservation to the contract, computers generically transfer data as a matter of course. Thus, Appellants have not shown sufficient why saying that the invention allows bypassing a counter is any more than saying that the invention uses a computer. As to reliance on a master rental agreement, there is nothing about a master rental agreement that mandates its use. It is simply a tool that is optional. Choosing not to use the tool is no more than choosing when to enter the data that would otherwise be stored in such a tool, and is both "abstract" and does not amount to "significantly more."

Claim 24 is argued on the same basis as claim 1. Reply Br. 7.

As to claim 15, reciting a selectable option to convert the claim 1 reservation into a contract, we are not persuaded by Appellants' argument concerning claim 15's one touch, two transactions. Reply Br. 13–14. This is no more than saying a computer stores data that are reusable. Simply reusing data across plural transactions is no more than abstract conceptual advice and, again, is not "significantly more."

Also as to claim 15, we are not persuaded by Appellants' argument that this is a technical innovation. Suppl. Br. 8. This limitation only makes the implication of claim 1's limitation of receiving acceptance being voluntary more explicit, and we are unpersuaded something voluntary is technical.

We are not persuaded by Appellants' argument that, as to claim 18, it automates license validation. Reply Br. 14–16. Appellants dispute that data validation is routine. *Id.* Data validation was too pervasive to seriously contend its ubiquity. FF 12–15.

As to claim 107, reciting data to associate the reservation and contract, and to flag the agreement, we are not persuaded by Appellants' argument that this is a technical innovation. Suppl. Br. 10. Absent a recited technical implementation, this is no more than conceptual advice to file the information together and highlight it, which is not technical.

As to claim 5, reciting prefilling contract data from the reservation, we are not persuaded by Appellants' argument that this is a technical innovation. Reply Br. 12. Absent a recited technical implementation, this is no more than conceptual advice to copy or otherwise reuse the data, which is not technical.

The remaining claims are argued in a manner similar to claim 1, or based on claim 1.

Claims 1–9, 11–13, 15–25, 27–32, 34–36, 38–80, 82–84, 90, 92–94, 100, and 104–114 rejected under 35 U.S.C. § 112, second paragraph, as failing to particularly point out and distinctly claim the invention

We are persuaded by Appellants' argument that the significance of the determining limitation does not render the claims indefinite. App. Br. 19–21.

Claims 1–9, 11–13, 15–25, 27–32, 34–36, 38–80, 82–84, 90, 92–94, 100, and 104–114 rejected under 35 U.S.C. § 103(a) as unpatentable over Hertz, Avis, and Hertz Gold

The independent claims describe the basic steps in contracting for a rental car. First the customer provides the information for basic availability, such as dates and location of pickup and return. The vendor then responds with what is available, and allows the customer to refine the request within those parameters, such as class of car and price levels. The customer then asks for a specific quote, and then, if the customer accepts, the customer provides license and credit card information if it is not already of record and contracts for the rental. The screen prints of the Hertz web site of record are evidence of this flow. FF 1.[4]

That the prior art describes the above is not in dispute. Instead, what is disputed is the timing and location of these steps. In particular, the claims recite that both the "user's future rental of a rental vehicle" (hereinafter "reservation") and contract are made in a single session, and this is done without the customer going to a customer service counter, and is done irrespective of whether there is some pre-existing relationship or agreement between the customer and the car rental company. Appellants argue that the prior art does not describe these limitations. Appellants also nominally contend the limitations regarding the reservation process are separated by some customer data entry steps, and the reservation and contract steps are separated by customer acceptance, but these arguments appear to be related to the single session argument as, again, whether Hertz discloses the basic flow of data is not in dispute.

Before analyzing the specific comparisons between the claims and the prior art, we will summarize the issues that these claims raise, because of their number and complexity. First, the claims recite data entry and little else. Data *per se* are no more than arbitrary (based on arbitrary coding conventions) strings of binary digits irrespective of the labels attached, and, without some explicit functionality dependent on the differences between the actual labels, the labels are afforded no patentable weight. Absent some

---

[4] We discern that the above flow comports with the common experience of anyone who has rented a car.

functional effect, there is no patentable distinction between a master rental agreement, a reservation, and a contract, as all are printed matter or binary data. Absent some functional effect, any legal effect attaching to a contract is a nullity in patent law. What is left is conventional data entry. Second, we find that it would have been predictable to consolidate data entry even if the labels were given patentable weight. FF 1–11. Third, we find that it would have been predictable for a customer to perform the same data entry that an agent at a customer service counter would perform. FF 10–11. Fourth, the above-cited prior art describes a promotional program that allows the customer to do just that and avoid a customer service counter. *Id.* Fifth, even if weight were afforded to the label of a master service agreement, we find that there is nothing about the absence of such an agreement or relationship that would present a logistical hurdle to entering the data related to a master agreement and reservation in a single session. FF 1–11. Sixth, even if the master rental agreement contains data necessary for a rental, we find that it would have been predictable to enter that same data during the reservation and contracting phases in the absence of a master rental agreement. *Id.* Seventh, we find that it was predictable to have a customer contract for the car immediately after and in the same session as obtaining a reservation. *Id.*

The dependent claims further recite driver license data entry and validation. We enter Gallian and Burch as new art that shows it was known to ask for such data and validate it online at the time of the invention.

Even before comparing the claims to the prior art, we discern that Appellants have a high hurdle in terms of claim breadth and patentable weight. The instant claims do not recite limitations not described in the prior art. Rather, the claims recite not requiring portions of the car rental experience that are described in the prior art. Removing something known from a known process, without changing the result of the process, is invariably predictable, unless the absence of that something is a technical barrier to the process. This is a corollary to the volition involved in performing the process and its steps. Nothing in the claims presents a technical barrier that is overcome by the steps recited. The claimed procedure is entirely volitional, and is unconstrained by inhibitory structure, physical properties, or attributes. Equally, the claims do not recite removing such a technical barrier. Instead, Appellants posit an industry convention of using a customer service counter and separating the reservation and contract in time, and it is this separation that they suggest circumventing. As a convention, there is nothing about using a service counter that makes avoiding it atypical. One of ordinary skill would have known that such a modification has readily apparent costs and benefits, and using a service counter or not using a service counter is simply based on weighing those readily apparent costs and benefits. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 421 (2007) ("A person of ordinary skill is also a person of ordinary creativity, not an automaton."); *Winner v. Wang*, 202 F.3d 1340, 1349 (Fed. Cir. 2000) ("the district court did not clearly err in finding that one of ordinary skill in the art would not have reasonably elected trading the benefit of security for that of convenience. Trade-offs often concern what is feasible, not what is, on balance, desirable. Motivation to combine requires the latter.")..

Appellants have not identified any technological hurdle in avoiding a customer service counter. The claims do not recite any action that would ordinarily otherwise require, as contrasted with prefer, such a counter. Appellants have not identified any technological hurdle to performing two sets of data entry in a single session. The claims do not recite any action that would ordinarily otherwise require, as contrasted with prefer, plural sessions. Appellants have not identified any technological hurdle to performing a second set of data entry in the same session as a first, irrespective of the existence of some relationship between the customer and the car rental company. The claims do not recite any action that would ordinarily otherwise require, as contrasted with preferr, premising a second data entry on the existence or lack thereof of such a relationship.

As to the issue of adding data, we find that data editing is a notoriously well-known mechanism where data, that were not there prior to the editing, are added; this is not a significant issue. More to the point, the distinct items of data that must be in place for a rental contract, but not necessarily for a reservation, are a credit card and driver license. FF 6, 10–11. We find that adding such data, after seeing that a rental is available in the form of a reservation, would not only have been predictable, but would have been immediately envisaged by one of ordinary skill. FF 10.

Not only would have avoiding a counter been predictable, HertzGold shows it was known to combine a reservation and contract in a single visit, and that avoiding such a counter was preferable. FF 10–11. Appellants counter that HertzGold requires a master agreement. But a master agreement is just data collected prior to a rental, as is a reservation. So, the issue devolves to the patentable weight afforded any distinction between data gathered prior to rental and data gathered at rental time at a customer service counter, and the predictability of combining such data gathering.

As to structural inventions, such claims must be distinguished from the prior art in terms of structure rather than function, *see, e.g.*, *In re Schreiber*, 128 F.3d 1473, 1477–78 (Fed. Cir. 1997). In order to satisfy the functional limitations in an apparatus claim, however, the prior art apparatus as disclosed must be capable of performing the claimed function. *Id.* at 1478. When the functional language is associated with programming or some other structure required to perform the function, that programming or structure must be present in order to meet the claim limitation. *Typhoon Touch Techs., Inc. v. Dell, Inc.*, 659 F.3d 1376, 1380 (Fed. Cir. 2011) (discussing *Microprocessor Enhancement Corp. v. Texas Instruments, Inc.*, 520 F.3d 1367 (Fed. Cir. 2008)). In some circumstances, generic structural disclosures may be sufficient to meet the functional requirements, *see Ergo Licensing, LLC v. CareFusion 303, Inc.*, 673 F.3d 1361, 1364 (Fed. Cir. 2012) (citing *Telcordia Techs., Inc. v. Cisco Sys., Inc.*, 612 F.3d 1365, 1376–77 (Fed. Cir. 2010)).

Also, a structural invention is not distinguished by the work product it operates upon, such as data in a computer. "[E]xpressions relating the apparatus to contents thereof during an intended operation are of no significance in determining patentability of the apparatus claim." *Ex parte Thibault*, 164 USPQ 666, 667 (Bd. App. 1969). Furthermore, "inclusion of material or article worked upon by a structure being claimed does not impart patentability to the claims." *In re Otto*, 312 F.2d 937, 940 (CCPA 1963).

As to process claims, claim 1 recites seven steps, viz., receive X, determine whether Y is true, irrespective of whether Y is true, communicate Z, receive W, and create and store U, where X is labeled as data being representative of a user's future rental of a rental vehicle, Y is labeled as the user has a defined pre-existing customer relationship with the rental car company, Z is labeled as an electronic rental proposal, and W is labeled as a completed electronic rental contract. Thus, the claim is really to accepting data and soliciting additional data, creating data and determining whether some criterion of data existence is met, and accepting, creating, and displaying more data. Nothing in the claim depends on or enforces the perceptual labels the claim suggests. Mental perceptions of what data represent are non–functional and given no weight. *King Pharm., Inc. v. Eon Labs, Inc.*, 616 F.3d 1267, 1279 (Fed. Cir. 2010) ("[T]he relevant question is whether 'there exists any new and unobvious functional relationship between the printed matter and the substrate.'") (citations omitted). *See also In re Lowry*, 32 F.3d 1579, 1583 (Fed.Cir.1994) (describing printed matter as "useful and intelligible only to the human mind") (quoting *In re Bernhart*, 417 F.2d 1395, 1399 (CCPA 1969)). Data labels are just examples of such mental perceptions. Data, being a succession of binary digits, are just those digits, not perceptual labels of those digits. The binary digits, at times, may impose some functional consequence, but absent some recitation of how so, such consequence is not an issue.

To put this in terms of the test put forward in *King*, nothing in the steps depends on or enforces the perception of the data labels and the data label perceptions do not functionally affect the steps. The Federal Circuit in *King* explicitly urged against non-functional limitations allowing the indefinite patenting of existing known processes by merely putting those processes in the context of such non-functional limitations. *King Pharm.,* 616 F.3d at 1279.

In particular, there is no patentable distinction between a master agreement, a rental reservation, and a rental contract. We are not persuaded by Appellants' argument that there are such distinctions. App. Br. 15–16. Although there may be legal distinctions between a reservation and a contract, absent some functional effect, which Appellants have not persuasively identified here, any such legal distinctions arise only in the mind of the beholder, and are relegated to the legal arts, as contrasted with the useful or technological arts. All are physically the same, viz. printed matter or an arbitrary succession of binary digits (in that any encoding scheme is arbitrary). Appellants cite evidence by a Declarant that additional information is needed in a contract. *Id.* As we find *supra*, absent some functional effect, which Appellants have not persuasively identified here, any distinctions between such data are, again, only in the mind of the beholder and do not affect the operations recited of receiving and sending data.

As a result, when giving the data labels recited in the claims no patentable weight, the independent claims devolve to data entry which is anticipated by any data entry reference, including those applied by the Examiner. FF 1–5. And even if the reservation and contract labels are afforded weight, we find that it would have been predictable to consolidate data entry operations. FF 7, 10–11. And even if the master rental agreement label is afforded weight, it would have been similarly predictable to consolidate data entry operations to that agreement, such that the entered data would not have been pre-existing, but instead would have been contemporaneously entered. We discern that consolidating data entry operations would have been predictable, because we find that there is a cost in terms of time separation and data entry overhead, in splitting such operations, that is saved with consolidation. FF 7, 10–11. As a corollary to data entry consolidation, we discern that it would have been predictable to have the customer enter the same data at his computer that a rental agent would have entered at a rental counter, for the same reason of cost reduction. *Id.* And although Hertz Gold requires a master rental agreement, there is nothing about such an agreement that would preclude entering the equivalent information during the reservation data entry, again for the benefits of data entry consolidation. *Id.* Both a rental counter and a master rental agreement are marketing and sales tools that provide an opportunity to upsell car class and accessories and instill loyalty. FF 6, 11. We find that their *raison d'être* is more marketing related than due to technical considerations. *Id.* It would have been predictable to avoid such marketing opportunities, where the benefits in data consolidation were available, particularly as we find that it was known to use a rental counter without a master agreement and *vice versa*. *KSR*, 550 U.S. at 421 ("A person of ordinary skill is also a person of ordinary creativity, not an automaton."); *Winner*, 202 F.3d at 1349 ("the district court did not clearly err in finding that one of ordinary skill in the art would not have reasonably elected trading the benefit of security for that of convenience. Trade-offs often concern what is feasible, not what is, on balance, desirable. Motivation to combine requires the latter.").

We are not persuaded by Appellants' argument that a pre-existing master rental agreement (MRA) is a technical requirement in Hertz Gold. App. Br. 18. Appellants only show that the Hertz Gold software happens to be programmed to require the MRA, not that the software must be so programmed. The distinction is that Hertz Gold programs its software to perform what Hertz desires, rather than what is technically required irrespective of Hertz's desires. The choice to predicate a step on an optional criterion is just that, a choice, based on tactical considerations. Anyone with minimal programming skills would have known how to overcome such an obstacle, viz, remove the check for the criterion. To the extent patentable weight were to be given to the data content in an MRA and reservation, we find that combining data entry was both known and predictable. FF 10–11. Appellants have not identified any timing issues related to the availability of information that were overcome by the claims. All the information needed from the customer in the MRA and contract is available to the customer at the time of reservation. The known benefit of combining data entry in avoiding delay and plural logs would have been sufficient reason for such a combination.

We are not persuaded by Appellants' argument that the prior art requires a two pass, rather than one pass, system, for similar reasons. Appellants have not identified any technical hurdle to overcome in combining data entry operations; it is only a question of volition. Hertz Gold shows that such combining of reservation and contract was known and practiced. FF 10–11. That Hertz Gold required an MRA is no more than additional data entry that one of ordinary skill would have immediately envisaged combining with the reservation.

We are not persuaded by Appellants' argument that the rejection failed to articulate the scope and content of the prior art, and differences from the claims. App. Br. 24. We summarized the Examiner's findings of such *supra*.

We are not persuaded by Appellants' argument that the prior art fails to describe a single visit. *Id.* We find that combining data entry would have been predictable to one of ordinary skill at the time of the invention, *supra*.

We are not persuaded by Appellants' argument that the Examiner cited the wrong pages of Hertz. *Id.* We find that this was an inadvertent typographical error, and that the appropriate portions of Hertz and Hertz Gold that the Examiner intended to cite are clear.

We are not persuaded by Appellants' argument that Hertz Gold discloses nothing about electronic rental contracts and how such electronic rental contracts can be created. App. Br. 30. The claim only recites receiving and sending data to create contracts. Hertz Gold describes as much. Contracts in computer memory are binary digits. How they are interpreted is a matter discernable only in the human mind. Thus, all we are left with is the creation of some data, which would have been known to one of ordinary skill at the time of the invention. Absent some functional effect, which Appellants have not persuasively identified here, whether the binary data, as interpreted, meets legal requirements is not a matter of patentability, but is a matter of legal rather than technological arts.

We are not persuaded by Appellants' argument that the Examiner failed to establish the level of skill of the person of ordinary skill. *Id.* It is well–settled that the presentation of the prior art itself reflects an appropriate level of ordinary skill in the art. *See Chore-Time Equip., Inc. v. Cumberland Corp.*, 713 F.2d 774, 779 (Fed. Cir. 1983). *See also Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001); *In re GPAC, Inc.*, 57 F.3d 1573, 1579 (Fed. Cir. 1995); *In re Oelrich*, 579 F.2d 86, 91 (CCPA 1978).

We are not persuaded by Appellants' argument that the Examiner failed to articulate why one of ordinary skill would have combined the references. *Id.* We find that the three references all describe the same process of car rental, albeit from differing perspectives. We are unpersuaded that the Examiner's proffered combination is anything more than a combination of familiar elements according to known methods that does no more than yield predictable results. *KSR*, 550 U.S. at 401.

As to separately argued claim 24, we are not persuaded by Appellants' argument that patentable weight must be afforded a claim element that provides functionality with respect to the end use of a claimed system. App. Br. 32. As set forth above, the test for whether a limitation is afforded patentable weight is whether the limitation affects or is affected by the recited operations, or whether the recited operations affect or are affected by the limitation. *King Pharm.*, 616 F.3d at 1279. Here, the recited operations are those of sending, editing, creating, and receiving data. The operations are not conditioned on the presence of certain data, as the claim and arguments expressly perform the operations irrespective of the presence or absence of certain data. As we find *supra*, these operations are insensitive to the labels attached to the data, and the data labels are unaffected by these operations.

We are not persuaded by Appellants' argument that

> the "electronic rental contract" authorizes the user "to pick up a rental vehicle in accordance with the completed electronic rental contract without the user visiting a rental counter" are inescapably intertwined with a functional effect of claim 24. The system of claim 24 can create an electronic rental contract for a user that permits such user to avoid creating a rental contract at the rental counter when arriving at

> the car rental facility to pick up a rental vehicle in accordance with the electronic rental contract, which ameliorates inconveniences for the user when picking up a rental vehicle. Thus, the system of claim 24 provides a user with opportunities and capabilities that did not exist before because the system of claim 24 lets a user create an "electronic rental contract" that authorizes the user "to pick up a rental vehicle in accordance with the completed electronic rental contract without the user visiting a rental counter" even if the user does not have a pre-existing MRA with the subject rental car company.

App. Br. 34. Authorization for a manual act is in the mind of the beholder; it is not a functional effect or result. There is nothing about a customer service counter that caused authorization in conventional rentals; the counter was just the conventional site for the transaction. Nothing about a rental transaction dictates such a site. Avoiding a counter does not affect the operations of sending, receiving, editing, and creating data. To the extent avoiding a counter affects the timing of those operations, we find that this would have predictable to one of ordinary skill, as described in Hertz Gold *supra*. FF 10–11.

We are not persuaded by Appellants' argument similar to the one just referred to, but with respect to avoiding the Master Rental Agreement. App. Br. 35. As we find *supra*, absent some functional effect, which has not been identified by Appellants, there is no patentable distinction between an MRA and a reservation, as both are merely binary data entered into a computer. And again, to the extent the argument is that the MRA contains data that are necessary for a contract that might not be entered into a reservation, this is not in the claim, and it would have been predictable to combine two separate data entry sessions into a single session where all the information is known. As by the terms of the claim, an MRA is pre-existing at the time of a reservation, all of the information would have been known at the time of the reservation. It would further have been predictable to enter the data for an MRA in the same session as a reservation, so that it is not pre-existing at the time of the session, for the purpose of meeting any such requirement for an MRA the first time a reservation is desired.

Claim 3 is argued on the basis of claim 1. App. Br. 36.

As to separately argued claim 15, we are not persuaded by Appellants' argument that the prior art fails to describe an option for converting a reservation into a contract. The argument refers to this as a one touch, two transaction combination. App. Br. 36–37. First, the claim does not recite a one touch, two transaction car rental limitation, as such. Second, the claim does not recite any car rental transaction *per se*, but only data entry, transmission, and reception. Third, again, absent some functional effect, which Appellants have not persuasively identified here, there is no patentable distinction between the contents of distinct data entry sessions based on their labels. Fourth, again, we find that it would have been predictable to combine two separate data entry sessions into a single session, to avoid time separation and data entry overhead. FF 7, 10-11. Fifth, Hertz Gold shows it was known to combine the reservation and contracting in a single session. FF 10–11

Claim 38 is argued on the basis of claim 15. App. Br. 37.

As to separately argued claim 18, we are not persuaded by Appellants' argument that the prior art fails to describe validating a driver license and conditioning the contract on this. App. Br. 38–39. We find that contracting for a car requires a valid driver license and credit card that are not necessarily required just to reserve a car.[5] FF 10. Automation of a known manual activity is obvious. *Leapfrog, id.* It is unnecessary to actually see a driver license to validate it because automated systems provide such validation services.[6] FF 12–15. One of ordinary skill would have known that it was the marketing promotional activities that prompted Hertz to require trips to the customer service counter, at least as much as having a suitable system electronically perform such validation, in view of the notoriety of much more secure and certain ways of automated validation. FF 6, 12–15. Auto rental companies were validating driver licenses online and checking driver records with those license numbers as early as 1993. Burch 1. Gallian shows that validating licenses based on the number pattern was known.[7] FF 15. One of ordinary skill would have known that a driver license number is just a data string that can be passed through to the validation services from the data entered by the customer.

Claim 41 is argued on the basis of claims 18 and 24. App. Br. 40.

We are not persuaded by Appellants' argument, as to claims 107 and 113, about data configured to flag the reservation and rental transaction as eligible for the user to pick up the rental vehicle, in accordance with the completed electronic rental contract, without the user visiting a rental counter. App. Br. 40–41. As we find *supra*, absent some functional effect, which has not been identified by Appellants, there is no patentable

---

[5] We discern that this comports with the experience of anyone renting a car.
[6] This is known to anyone who has ever been pulled over in a car by a policeman or seen a representation of this on television.

distinction among a reservation, transaction, and contract. As the claims recite no particular implementation for how the configuration is flagged, such flagging is no more than some convention adopted by the programmer. As the claims do not recite flagging as an alternative to ineligible, any convention showing that the data may be usable as a contract would be within the claim scope. Again, we find that it was predictable to store the data as being usable for a contract.

We are not persuaded by Appellants' argument as to claims 5, 69, 82, 105, and 109, and claims 28, 106, 110, 111, 112, and 114, about prefilling data from a master agreement. App. Br. 41–42. Hertz describes using the master agreement for a reservation (FF 7), and we discern that implementing the reverse, prefilling the reservation from the agreement, would have been known to and within the abilities of one of ordinary skill. *In re Gazda*, 219 F.2d 449 (CCPA 1955). As we find *supra*, there is no patentable distinction among a reservation, transaction, and contract. As the claims recite no particular implementation for how the data is prefilled, any disclosure using the master agreement data would be within the claim scope. Hertz describes using such master agreement data for a contract. FF 7.

We are not persuaded by Appellants' argument as to claims 6, 70, and 29 about modifying data without modifying a master agreement. App. Br. 42–43. As we find *supra*, absent some functional effect, which has not been identified by Appellants, there is no patentable distinction among a reservation, transaction, and contract. As the claims recite no particular

---

[7] Beyond that, we discern that the notoriety of hashing as an additional check on validity was too notorious at the time of filing to consider this

implementation for how the data are modified, or that the data must come from master agreement, any disclosure showing that the data would have been entered from the reservation, or from customer data entry, would be within the claim scope. FF 2, 3, 6, 10-11. Again, we find that it would have been predictable to enter data usable for a contract.

We are not persuaded by Appellants' argument as to claims 7, 71, and 30 about an option to keep modifications or revert data. App. Br. 43–44. As we find *supra*, absent some functional effect, which has not been identified by Appellants, there is no patentable distinction among a reservation, transaction, and contract. As the claims recite no particular implementation for how the data are modified, or that the data must come from the master agreement, any disclosure showing that the data would have been edited from the reservation, customer data entry, or the master agreement would be within the claim scope. Again, we find that it would have been predictable to edit the data from any available source (FF 2, 3, 6, 10-11), and the notoriety of UNDO as an editing feature obviates any issue of the predictability of reverting data. Although Appellants are correct that UNDO is a generic command for cancelling the most recent command, which may or may not be modification of data, we find that for data modification, which is disclosed by the cited references, as indicated above (FF 2), user selection of the UNDO feature would result in a data reversion.

Arguments as to the remaining claims are repetitions of the above arguments.

---

unpredictable.

We have reviewed the Declarations by Mr. Smith and find them unpersuasive.

> The Board has broad discretion as to the weight to give to declarations offered in the course of prosecution. *See Velander v. Garner,* 348 F.3d 1359, 1371 (Fed. Cir. 2003) ("[A]ccord[ing] little weight to broad conclusory statements [in expert testimony before the Board] that it determined were unsupported by corroborating references [was] within the discretion of the trier of fact to give each item of evidence such weight as it feels appropriate."); cf. *Ashland Oil, Inc. v. Delta Resins & Refractories, Inc*., 776 F.2d 281, 294 (Fed. Cir. 1985) ("Opinion testimony rendered by experts must be given consideration, and while not controlling, generally is entitled to some weight. Lack of factual support for expert opinion going to factual determinations, however, may render the testimony of little probative value in a validity determination." (citations omitted)). Although there is "no reason why opinion evidence relating to a fact issue should not be considered by an examiner," *In re Alton*, 76 F.3d 1168, 1175 n.10 (Fed. Cir. 1996), the Board is entitled to weigh the declarations and conclude that the lack of factual corroboration warrants discounting the opinions expressed in the declarations, *see Velander*, 348 F.3d at 1371; *Ashland Oil*, 776 F.2d at 294.

In re American Academy of Science 367 F.3d 1359, 1368 (Fed. Cir. 2004). We find that Mr. Smith's Declarations describe conventional practices in the rental industry and not technical hurdles that were difficult to overcome. Choosing whether to allow a computer or a human to interact in converting a reservation to a contract is no more than a decision weighing (i) the marketing opportunity and adaptability of human intervention against (ii) the speed and efficiency of automation. One of ordinary skill would have known to weigh one more heavily than the other based on various factors, such as corporate strategy in demonstrating handholding and tactics in reducing time a customer has to spend in administration. Simply because a practice was conventional does not mean a different practice was unknown, unpredictable, or disparaged.

Because we introduce additional art and apply reasoning beyond that of the Examiner, we denominate this as a new ground of rejection to afford Appellants an opportunity for response.

CONCLUSIONS OF LAW

The rejection of claims 1–9, 11–13, 15–25, 27–32, 34–36, 38–80, 82–84, 90, 92–94, 100, and 104–114 under 35 U.S.C. § 101 as directed to non–statutory subject matter is proper.

The rejection of claims 1–9, 11–13, 15–25, 27–32, 34–36, 38–80, 82–84, 90, 92–94, 100, and 104–114 under 35 U.S.C. § 112, second paragraph, as failing to particularly point out and distinctly claim the invention is improper.

The rejection of claims 1–9, 11–13, 15–25, 27–32, 34–36, 38–80, 82–84, 90, 92–94, 100, and 104–114 under 35 U.S.C. § 103(a) as unpatentable over Hertz, Avis, and Hertz Gold is proper, but with the addition of new art is denominated as new grounds of rejection.

DECISION

The rejection of claims 1–9, 11–13, 15–25, 27–32, 34–36, 38–80, 82–84, 90, 92–94, 100, and 104–114 is affirmed.

Our decision is not a final agency action.

This decision contains new grounds of rejection pursuant to 37 C.F.R. § 41.50(b). Section 41.50(b) provides "[a] new ground of rejection pursuant to this paragraph shall not be considered final for judicial review." Section 41.50(b) also provides:

> When the Board enters such a non-final decision, the appellant, within two months from the date of the decision, must exercise one of the following two options with respect to the new ground of rejection to avoid termination of the appeal as to the rejected claims:
>
> (1) *Reopen prosecution.* Submit an appropriate amendment of the claims so rejected or new Evidence relating to the claims so rejected, or both, and have the matter reconsidered by the examiner, in which event the prosecution will be remanded to the examiner. The new ground of rejection is binding upon the examiner unless an amendment or new Evidence not previously of Record is made which, in the opinion of the examiner, overcomes the new ground of rejection designated in the decision. Should the examiner reject the claims, appellant may again appeal to the Board pursuant to this subpart.
>
> (2) *Request rehearing.* Request that the proceeding be reheard under § 41.52 by the Board upon the same Record. The request for rehearing must address any new ground of rejection and state with particularity the points believed to have been misapprehended or overlooked in entering the new ground of rejection and also state all other grounds upon which rehearing is sought.

Further guidance on responding to a new ground of rejection can be found in the Manual of Patent Examining Procedure § 1214.01.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a).
See 37 C.F.R. § 1.136(a)(1)(iv) (2011).

AFFIRMED; 37 C.F.R. § 41.50(b)

Notice of References Cited	Application/Control No. 12/650,113	Applicant(s)/Patent Under Patent Appeal No. 2015-002128	
	Examiner	Art Unit 3622	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-			
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	A.D.BURCH, RENTAL CAR COMPANIES CHECK DRIVERS' RECORDS, AUGUST 12, 1993
	V	JOSEPH A. GALLIAN, ASSIGNING DRIVER'S LICENSE NUMBERS, VOL. 64 NO. 1, FEBRUARY 1991
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Rental Car Companies Check Drivers` Records

August 12, 1993 | By A.D. BURCH, Staff Writer

Your driving record affects more than your pride or pocketbook under policies adopted recently by the nation`s largest car rental agencies.

Budget, Avis, Hertz and National are refusing to rent vehicles in some states to drivers with poor or tainted records, a move to lower the cost of soaring liability costs.

The leasing agencies are now checking state motor vehicle records by computer before consumers can get the keys. The driving record check is supposed to take less than a minute, so it is not expected to delay getting a car rental.

Fort Lauderdale-based Alamo Rent A Car, is also considering a policy involving drivers` checks, but the details are being worked out, said Liz Clark, director of public affairs.

Leasing officials point to this multimillion-dollar phrase: ``vicarious liability,`` as the reason for the new policies. Vicarious liability is a law in New York and Florida allowing the owners of the vehicle to be held liable even if the customer caused the accident.

``The cost of injuries is skyrocketing,`` said The Hertz Corporation spokesman Joe Russo, although he did not have specific figures. ``Just by virtue of us owning the car, we have to take the hit. So we are now trying to identify the high-risk drivers and (say) they are no longer entitled to the privilege of renting a car.``

The program is limited to drivers in states where the program is operating, including Florida, New York, Maryland and Ohio. For example, a New York- registered driver would be screened when attempting to rent a car in Florida but not Utah, where the program is not being used.

Hertz, National and Budget report a denial rate that peaked at 10 percent of the drivers whose licenses were checked. That rate has stabilized at 6 percent. The companies declined to release total leasing numbers.

Hertz, based in Park Ridge, N.J., began its program in July 1992 in New York. It brought Florida on-line in April and the greater Washington, D.C., area in June. The company has made preliminary plans to add California later this year. Avis launched its program for Florida and New York drivers about a month ago. Likewise, National and Budget adopted their policies late last year.

``The (Division of Motor Vehicles) is a tool to help us overcome difficulties in doing business,`` said Michael Olsen, spokesman for the Minneapolis-based National Car Rental System Inc. ``It also helps with the safety issue.``

Companies do not have access to motor vehicle records so they contract with TML Informational Services, of Forest Hills, N.Y., which had direct access to the DMV databases. Rental agents enter the driver`s license number into the computer system. A TML representative runs the number and kicks back a computer answer to the rental agent within 30 seconds, based on a series of criteria.

Although the rules vary among the companies, the red flag or denial usually bleeps across the computer screen if a driver has a suspended, expired or revoked licenses, a history of driving under the influence, driving without insurance or a license, or posssession of a stolen car.

In beginning the safe-driving program, the companies also launched a consumer awareness campaign.

Related Articles

Check Safety Recalls On Cars, Boats, Medicine
July 27, 2009

Law Bans Open Containers Of Alcohol In Motor Vehicles
April 2, 1986

Failure To Pay Child Support Could Mean Losing License
May 4, 1995

Drivers May Catch A Break On Auto Tags
January 5, 2000

Unlicensed Driver Dies In Accident On I-95
June 26, 1997

Find More Stories About

Motor Vehicles

``We have posted signs at the rental counters and our reservation sales agents (headquartered) in Tulsa (Okla.) will tell Florida and New York consumers they are likely to run a check on their licenses so they are not surprised when it pops up,`` said Ray Noble, spokesman for the Garden City, N.Y.-based Avis Inc.

BAD DRIVERS BEWARE

The criteria for vehicle leasing vary by company. Here are the basic criteria used by Hertz and Avis:

1. Driver`s license suspended, revoked, invalid, surrendered or expired, if not cleared.

2. Eight or more points on driving record within the past 24 months (48 months for reckless disregard for life and property). Department of Motor Vehicle Accident Prevention credits are taken into consideration.

3. Conviction for DWI/DWAI/DUI within past 72 months.

4. Three or more convictions for moving violations within past 36 months.

5. Two or more accidents within past 36 months.

6. One or more accidents resulting in fatality or bodily injury within past 48 months. (This applies only to rentals in New York area; Avis does not use this criterion.)

7. Failure to report an accident or leaving the scene of an accident within the past 48 months.

8. Operating a motor vehicle without insurance or a valid driver`s license within the past 48 months.

9. Permitting operation of a motor vehicle without insurance or unlicensed operation of a motor vehicle within past 48 months.

10. Possession of stolen vehicle or use of a vehicle in a crime within 48 hours.

Assigning Driver's License Numbers

JOSEPH A. GALLIAN
University of Minnesota
Duluth, MN 55812

"You know my name
look up the number"

John Lennon and Paul McCartney, *You know my name*, single, B-side of *Let it be*, March 1970.

Introduction

Among the individual states, a wide variety of methods are used to assign driver's license numbers. The three most common methods, a sequential number, the social security number, and a computer-generated number, are uninteresting mathematically. On the other hand, many states encode data such as month and date of birth, year of birth, and sex in ways that involve elementary mathematics. Seven states go so far as to employ a check digit for possible detection of forgery or errors. Several states assign driver's license numbers by applying complicated hashing functions to the first, middle, and last names and formulas or tables for the month and date of birth. Surprisingly, the assignment of numbers is not always injective. In Michigan, for instance, there are 56 numbers whose inverse image has two or more members. New Jersey incorporates eye color into the number. Some states keep their method confidential. In a few instances, administrators of the license bureaus do not know the method used to assign numbers in their state! In this paper we discuss some of the methods we have uncovered.

Check Digit Schemes in General Use

Schemes for the assignment of identification numbers are extremely varied in methodology and in the information encoded. Most interesting to mathematicians are those that incorporate an extra digit for the detection of errors or fraud. Although the purpose of this paper is to analyze the methods used for driver's license numbers, it is worthwhile to begin with a brief survey of the methods employed to assign check digits to the most ubiquitous numbers in use and to provide a theoretical result that delineates their limitations.

The simplest and least effective method for assigning a check digit is to use the remainder or inverse of the remainder of the identification number modulo some number. For airline tickets, UPS packages, and Federal Express mail the check digit is the identification number modulo 7. At the bottom of FIGURE 1 we see the airline ticket number 17000459570 (the airline code 012 is not used in the calculation) is assigned a check digit 3 since $17000459570 \equiv 3 \bmod 7$.

U.S. postal money orders use the remainder modulo 9 while VISA traveler's checks use the inverse of the number modulo 9. Thus, the check digit for the VISA number 1002044679091 is 2 since $1002044679091 \equiv 7 \bmod 9$.

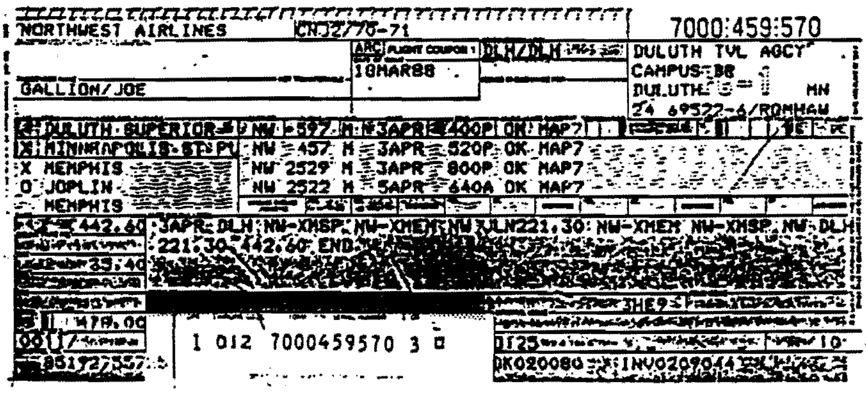

FIGURE 1
Airline ticket with number 17000459570 and check digit 3.

The modulo 7 schemes detect all errors involving a single digit except those where b is substituted for a and $|a-b|=7$. Likewise, an error of the sort $\cdots a_i \cdots a_j \cdots \to \cdots a_j \cdots a_i \cdots$ will go undetected if $|a_i - a_j| = 7$ or if 6 divides $j-i$.

The modulo 9 schemes are slightly better at detecting single-digit errors: Only a substitution of a 9 for a 0 or vice versa goes undetected. On the other hand, the only errors of the form $\cdots a_i \cdots a_j \cdots \to \cdots a_j \cdots a_i \cdots$ that are undetected are those involving the check digit itself. (A quick proof of this is to observe that the residue of a number modulo 9 is the residue of the sum of its digits modulo 9.)

Nearly all methods for assigning a check digit to a string of digits involve a scalar product of two vectors and modular arithmetic. For a string $a_1 a_2 \cdots a_{k-1}$ and a modulus n, many schemes assign a check digit a_k so that

$$(a_1, a_2, \ldots, a_k) \cdot (w_1, w_2, \ldots, w_k) \equiv 0 \bmod n.$$

We call such schemes *linear* and we call the vector $(w_1, w_2, \ldots, w_k)$ the *weighting vector*. The Universal Product Code (UPC) used on grocery items employs the weighting vector $(3,1,3,1,3,1,3,1,3,1,3,1)$ with $n=10$; the International Standard Book Number (ISBN) utilizes $(10,9,8,7,6,5,4,3,2,1)$ and $n=11$; banks in the U.S. use $(7,3,9,7,3,9,7,3,9)$ with $n=10$; many Western countries use $(7,3,1,7,3,1,\ldots)$ with $n=10$ to assign check digits to numbers on passports. Notice that the division schemes mentioned at the outset of this section are also linear with weighting vectors of the form $(10^{k-2}, 10^{k-3}, \ldots, 10^0, \pm 1)$.

The error-detecting capability of linear schemes is given by the following theorem.

THEOREM. *Suppose a number $a_1 a_2 \cdots a_k$ satisfies the condition $(a_1, a_2, \ldots, a_k) \cdot (w_1, w_2, \ldots, w_k) \equiv 0 \bmod n$. Then the single error occasioned by substituting a_i' for a_i is undetectable if and only if $(a_i' - a_i)w_i$ is divisible by n and a sole error of the form $\cdots a_i \cdots a_j \cdots \to \cdots a_j \cdots a_i \cdots$ is undetectable if and only if $(a_i - a_j)(w_i - w_j)$ is divisible by n.*

Proof. If a_i' is substituted for a_i, then the dot product of the correct number and the incorrect number differ by $(a_i' - a_i)w_i$. Thus, the error is undetected if and only if $(a_i' - a_i)w_i \equiv 0 \bmod n$.

Now consider an error of the form $\cdots a_i \cdots a_j \cdots \to \cdots a_j \cdots a_i \cdots$. Here the dot product of the correct number and the incorrect number differ by

$$(a_i w_i + a_j w_j) - (a_j w_i + a_i w_j) = (a_i - a_j)(w_i - w_j)$$

The conclusion now follows as before.

Since the most common moduli are 10 and 11, the following corollary is worth mention.

COROLLARY. *Suppose an identification number* $a_1 a_2 \cdots a_k$ *satisfies*

$$(a_1, a_2, \ldots, a_k) \cdot (w_1, w_2, \ldots, w_k) \equiv 0 \bmod n$$

where $0 \leqslant a_i < n$ *for each* i. *Then all single-digit errors occurring in the ith position are detectable if and only if* w_i *is relatively prime to* n *and all errors of the form* $\cdots a_i \cdots a_j \cdots \to \cdots a_j \cdots a_i \cdots$ *are detectable if and only if* $w_i - w_j$ *is relatively prime to* n.

The above theorem verifies our claims about the error-detection capability of the schemes used on money orders and airline tickets. It also explains why the bank and passport schemes will detect some errors of the form $\cdots abc \cdots \to \cdots cba \cdots$ while the UPC code will detect no such errors. Observe that because 11 is prime the ISBN code detects 100% of all single-digit errors and 100% of all errors involving the interchange of two digits. But there is a price to pay for using the modulus 11: The number a_k needed to satisfy the condition may be 10, which is two digits. In this case, an alphabetic character such as X or A is used or such numbers are not issued. As we will see below there are schemes that use the modulus 11 that do not resort to an alphabetic character, but there is a price to pay for this too: Not all transposition errors are detectable. More information about check digits schemes in use can be found in [1], [2], [3], [4], [6], [7], [8].

Check Digits on Driver's License Numbers

The state of Utah assigns an eight-digit driver's license number in sequential order, say $a_1 a_2 \cdots a_8$, then appends a check digit a_9 using a linear scheme with weighting vector $(9, 8, 7, 6, 5, 4, 3, 2, 1)$ and modulus 10. This method is identical to that used by the American Chemical Society for its chemical registry numbers. Assuming that all errors are equally likely,[1] this method detects $73/81$ or 90.1% of all single-digit errors and 100% of all transposition errors (i.e., errors of the form $\cdots ab \cdots \to \cdots ba \cdots$).[2]

To verify the single-error detection rate, observe from our theorem that in positions 2, 4, 6, and 8 substitution of b for a will go undetected when $|a - b| = 5$; in position 5, a substitution of b for a will go undetected when a and b have the same parity. Thus in each of positions 2, 4, 6, and 8 there are 10 undetected errors among 90 possible errors while in the fifth position, 40 of the 90 possible errors are undetected.

[1] In practice all errors are not equally likely. One study [7, p. 15] revealed that a substitution of a "5" for a "3" was 17 times as likely as a substitution of a "9" for a "1." However, available data are insufficient to assign reliable probabilities to the various error possibilities.

[2] A highly publicized error of this kind recently occurred when Lt. Col. Oliver North gave U.S. Assistant Secretary of State Elliot Abrams an incorrect Swiss bank account number for depositing $10 million for the contras. The correct number begins with "386"; the number North gave to Abrams begins with "368."

So, in all, 80 of 810 errors are undetected.

Someone working for the Canadian province of Quebec, probably having seen a scheme like the one used by Utah somewhere, came up with the laughable weighting vector $(12, 11, 10, 9, \ldots, 2, 1)$ with modulus 10 to assign a check digit. Of course, any error in the third position is undetectable and weights of 12 and 11 have the same effect as the weights 2 and 1.

Newfoundland uses the weighting vector $(1,2,3,4,5,6,7,8,1)$ with modulus 10. This is nearly identical to the Utah scheme except that it will not detect the event that the first and last digit are interchanged.

Three states use a modified linear scheme with modulus 11. New Mexico and Tennessee append a check digit a_8 to $a_1a_2 \cdots a_7$ as follows: First calculate

$$x = -(a_1, a_2, \ldots, a_7) \cdot (2,7,6,5,4,3,2) \bmod 11.$$

If $x = 0$, a_8 is 1; if $x = 10$, $a_8 = 0$; otherwise $a_8 = x$. This method catches 100% of all single-digit errors. Furthermore, the only errors of the form $\cdots a_i \cdots a_j \cdots \to \cdots a_j \cdots a_i \cdots$ that go undetected are those where $i = 1$ and $j = 7$ (an unlikely error indeed) and some involving the check digits 0 and 1. Assuming that all transposition errors are equally likely,[3] this method detects 98.2% of such errors. The Vermont scheme is the same as the one used by New Mexico except that when $x = 0$, the letter "A" is the check. This method, like the ISBN method, yields a 100% detection rate for both single-digit and transposition errors, but utilizes two formats for numbers. Notice that there would be nothing lost if the weighting vector began with 8 instead of 2 and there would be a slight gain since errors of the form $a_1a_2 \cdots a_7a_8 \to a_7a_2 \cdots a_1a_8$ would be detectable.

The state of Washington and the province of Manitoba use a check digit scheme devised by IBM in 1964 to assign a check digit. The license number is a blend of 12 alphabetic and numeric characters. To compute the Washington check digit, alphabetic characters are assigned numeric values as follows: $* \to \emptyset$, $A \to 1$, $B \to 2, \ldots, I \to 9$, $J \to 1$, $K \to 2, \ldots, R \to 9$, $S \to 2$, $T \to 3, \ldots, Z \to 9$. (Notice the aberration at S.) The 12-character license number, after an alphabetic to numeric conversion, then corresponds to a string of digits $a_1a_2 \cdots a_{12}$ with a_{10} as the check digit calculated as $|a_1 - a_2 + a_3 - a_4 + \cdots + a_9 - a_{11} + a_{12}| \pmod{10}$. Interestingly, the use of the absolute value actually makes the method nonlinear and reduces the error detection capability of the scheme. It would have been better to use the linear scheme with weighting vector $(1, 9, 1, 9, \ldots, 1) \bmod 10$.

South Dakota and Saskatchewan employ another nonlinear scheme developed by IBM to assign its check digit. In South Dakota, a six-digit computer-generated string is assigned a check digit as follows. Each of the second, fourth, and sixth digits is multiplied by 2 and the digits of the resulting products are summed (e.g., a 7 yields $1 + 4 = 5$ while a 3 yields 6). This resulting total is then added to the digits in the first, third, and fifth positions. The check digit is the inverse modulo 10 of this tally. (Alternatively, the check digit is $(10 - ((\Sigma_{i \text{ even}} (2a_i + \lfloor 2a_i/10 \rfloor) + \Sigma_{i \text{ odd}} a_i) \pmod{10})) \bmod 10$.) Thus, the check digit for 263743 is $-(1 + 2 + 1 + 4 + 6 + 2 + 3 + 4) \bmod 10 = 7$. This method is used by credit card companies, many libraries, and drug stores in the U.S. and by banks in West Germany, although in some instances it is the digits in the odd positions that are multiplied by 2. It detects 100% of all

[3] In reality, the likelihood of a transposition error depends on the pair of digits as well as the positions. But as before, reliable data for these occurrences are unavailable.

single-digit errors and 97.8% of transposition errors. To see that all single-digit errors are detected, observe that distinct digits contribute distinct values to the sum. To compute the detection rate for errors of the form $\cdots ab \cdots \to \cdots ba \cdots$, suppose such an error is undetected. We consider four cases. For simplicity, assume a in the correct number is in position 2, 4 or 6. The alternative case gives the same result.

Case 1. $a, b < 5$
Then $2a + b \equiv 2b + a \bmod 10$.
Thus $a - b = 0$ and $a = b$.

Case 2. $a < 5$, $b \geqslant 5$
Then $2a + b \equiv 2b - 9 + a \bmod 10$.
It follows that $b - a = 9$ so that $b = 9$ and $a = 0$.

Case 3. $a \geqslant 5$, $b < 5$
Then $2a - 9 + b \equiv 2b + a \bmod 10$.
So, $a - b = 9$ and $a = 9$ and $b = 0$.

Case 4. $a \geqslant 5$, $b \geqslant 5$
Then $2a - 9 + b \equiv 2b - 9 + a \bmod 10$.
Thus $a - b = 0$ and $a = b$.

So all transposition errors except $09 \leftrightarrow 90$ are detected. Since there are 90 possible transposition errors, the error detection rate is 88/90 or 97.8%.

It is worth noting that Gumm [4] has shown that it is not possible to improve upon these rates with any system that uses addition modulo 10 to compute the check digit without utilizing an extra character, as was the case for the New Mexico scheme.

Wisconsin appends a check digit to a 13-digit string. Unfortunately, I have not been able to figure out how this scheme works. I know it isn't linear; for if so, the weighting vector $(w_1, w_2, \ldots, w_{13}, w_{14})$ could be determined by gathering up a large number of valid license numbers to produce a system of linear equations with the w_i's as the unknowns. I have done this for modulo 10 and 11 to no avail. To circumvent any peculiarity that might arise involving a check digit of 10 in a modulo 11 scheme (e.g., New Mexico), I avoided numbers with a check digit of 0 or 1.

Encoding Personal Data

Here is the driver's license number of a Wisconsin resident: E 425-7276-9176-07. What information about the holder can you deduce from this number: year of birth, day and month of birth, sex, name? None of these is obvious. Let's go the other direction. I am a resident of Minnesota. I was born on January 5, 1942, and my middle name is Anthony. From this can you deduce my driver's license number?

Eleven states assign their driver's license numbers with hashing functions applied solely to personal data. A good hash function should be fast and minimize collisions (see [5, pp. 506–544] for a detailed discussion of this topic). Of course, there will be occasions when two or more individuals have enough personal data in common that collisions will occur. Most states have a tie-breaking mechanism to handle this situation. Coding license numbers only from personal data enables automobile insurers, government entities, and law enforcement agencies to determine the numbers when necessary.

Washington uses a complicated blend of name, check digit, and codes for the month and date of birth to assign its numbers. This 12-digit identifier consists of the first five letters of the surname; the first and middle initials (* is used when a name has less than five characters, or there is no middle initial); the year of birth subtracted from 100 (we suspect this is done to disguise the year of birth); a check digit; a code for the month of birth; and a code for the day of birth. For instance, Fielding Mellish (no middle name) born on 10/29/42 receives the identifier MELLI F* 587P9. When checked against a file of 1.6 million items, this scheme yielded duplicates at the rate of 0.03% and only one number appeared as many as four times. (Most of the duplications represented twins.) To ensure that the correspondence between individuals and numbers is injective, 17 alternate codes for month and year of birth are available. For example, an S can be used instead of a B for January or a Z instead of a 9 for the year of birth. Interestingly, the check digit is invariant under all alternate coding. The primary code and one alternate for months is given in TABLE 1 and the code for the days is given in TABLE 2. Notice the absence of completely predictable patterns.

TABLE 1. Washington code for months.

Months	Codes	Alternate Codes
January	B	S
February	C	T
March	D	U
April	J	1
May	K	2
June	L	3
July	M	4
August	N	5
September	O	6
October	P	7
November	Q	8
December	R	9

TABLE 2. Washington code for days.

1 - A	7 - G	13 - L	19 - R	25 - 5	31 - U
2 - B	8 - H	14 - M	20 - 0	26 - 6	
3 - C	9 - Z	15 - N	21 - 1	27 - 7	
4 - D	10 - S	16 - W	22 - 2	28 - 8	
5 - E	11 - J	17 - P	23 - 3	29 - 9	
6 - F	12 - K	18 - Q	24 - 4	30 - T	

Illinois, Florida, and Wisconsin encode the surname, first name, middle initial, date of birth, and sex by a quite sophisticated scheme. The first character of the license number is the first character of the name. The next three characters are obtained by applying the "Soundex Coding System" to the surname as follows:

1. Delete all occurrences of h and w.
2. Assign numbers to the remaining letters as follows:
   $b, f, p, v \to 1$ $\quad$ $l \to 4$
   $c, g, j, k, q, s, x, z \to 2$ $\quad$ $m, n \to 5$
   $d, t \to 3$ $\quad$ $r \to 6$
   (No values are assigned to a, e, i, o, u, and y.)
3. If two or more letters with the same numeric value are adjacent, omit all but the first. (Here a, e, i, o, u, and y act as separators.) For example, Schworer becomes Sorer and Hughgill becomes Ugil.

4. Delete the first character of the original name if still present.
5. Delete all occurrences of a, e, i, o, u, and y.
6. Use the first three digits corresponding to the remaining letters; append trailing zeros if less than three letters remain.

Here are some examples: Schworer → S-660; Hughgill → H-240; Skow → S-000; Sachs → S-200; Lennon → L-550; McCartney → M-263.

We parenthetically remark that the Soundex System was designed so that likely misspellings of a name would nevertheless result in the correct coding of the name. For example, frequent misspellings of my name are: Gallion, Gillian, Galian, Galion, Gilliam, Gallahan, and Galliam. Observe that all of these yield the same coding as Gallian. We also mention that the above method differs somewhat from the system called Soundex by Knuth in [5, p. 392].

The next three digits are determined by summing numbers that correspond to the first name and middle initial. The scheme for doing this begins with the block 000 for the letter A and makes jumps of 20 for especially common names and each subsequent letter of the alphabet. A small portion of this scheme is given in Table 3. The values assigned to the middle initial are given in Table 4.

So Aaron G. Schlecker would be coded as S426-007 (S426 from Schlecker; 000 for Aaron +7 for "G"), while Anne P. Schlecker would be coded as S426-055.

The last five digits of Illinois and Florida numbers capture the year and date of birth as well as the sex. In Illinois, each day of the year is assigned a three-digit number in sequence beginning with 001 for January 1. However, each month is assumed to have 31 days. Thus, March 1 is given 063. These numbers are then used to identify the month and day of birth of male drivers. For females, the scheme is identical except January 1 begins with 601. The last two digits of the year of birth, separated by a dash (probably for camouflage), are listed in the 5th and 4th positions from the end of the driver's license number. Thus, a male born on July 18, 1942, would have the last five digits 4-2204 while a female born on the same day would have 4-2804. When necessary, Illinois adds an extra character to avoid duplications.

TABLE 3. Illinois, Florida, Wisconsin given name or first initial code.

000	–	*A*
020	–	Albert, Alice
040	–	Ann, Anna, Anne, Annie, Arthur
060	–	*B*
080	–	Bernard, Bette, Bettie, Betty
100	–	*C*

TABLE 4. Illinois, Florida, Wisconsin middle initial code.

0 - none	10 - J
1 - A	11 - K
2 - B	12 - L
3 - C	13 - M
4 - D	14 - N, O
5 - E	15 - P, Q
6 - F	16 - R
7 - G	17 - S
8 - H	18 - T, U, V
9 - I	19 - W, X, Y, Z

Among the 9,397,518 licenses on file on January 1, 1987, this occurred in 14,856 instances. Of these, 55 numbers corresponded to three individuals (excluding the extra digit). No number corresponded to more than three people.

The scheme to identify birthdate and sex in Florida is the same as Illinois except each month is assumed to have 40 days and 500 is added for women. For example, the five digits 49583 belong to a woman born on March 3, 1949.

Wisconsin employs the same scheme as Florida to generate the first 12 of their 14 characters. The thirteenth character is an integer issued sequentially beginning with 0 to people who share the same first 12 characters. The fourteenth character is a check digit.

A Missouri driver's license number has 16 characters. The first 13 characters are obtained by applying a hashing function to the first five letters of the surname, the first three letters of the first name and the middle initial. (The method of encoding is similar to that used by Florida.) The final three characters are a function of the month and day of birth and sex. For a male born in month m and day d the three digits are $63m + 2d$. For a female, the corresponding formula is $63m + 2d + 1$. Thus the number of a woman born on March 4 has the final three characters 198. To avoid duplications, Missouri assigns a 17th character. Among the first 3,921,922 numbers issued, 31,719 have a 17th character.

Last, we discuss the scheme employed by Minnesota, Michigan, and Maryland. The number is a function of last name, first name, middle name, month and date of birth. The first four characters are determined by the Soundex System, as was the case for Illinois, Florida, and Wisconsin. The first and middle names account for the next six characters and the same algorithm is applied to both names. In the majority of cases the first two characters of the name determine the desired three digits for each name (see TABLE 5 for a sample); for common pairs of leading letters such as Al or Ja, the third letter is invoked (see TABLE 6); 11 three-digit numbers are uniquely assigned to the 11 most popular names (e.g., 189 ↔ Edward; 210 ↔ Elizabeth).

TABLE 5. Minnesota, Michigan, Maryland code for first and middle names beginning with *A* except *Al*.

		A	027		
Aa	028	*Aj*	037	*As*	072
Ab	029	*Ak*	038	*At*	073
Ac	030	*Al*	—	*Au*	074
Ad	031	*Am*	066	*Av*	075
Ae	032	*An*	067	*Aw*	076
Af	033	*Ao*	068	*Ax*	077
Ag	034	*Ap*	069	*Ay*	078
Ah	035	*Aq*	070	*Az*	079
Ai	036	*Ar*	071		

The final three digits are based on month and date of birth (but not year). Each day of the year is assigned a three-digit number in a monotonically increasing fashion. Although the usual pattern is to alternate increments of 3 and 2, there are numerous seemingly random increments at unpredictable dates. The month of March illustrates this behavior well. Notice from TABLE 7 that March 1 is assigned 159. Subsequent days are assigned values by increments of 3 and 2 in alternating fashion until March 8. Then there is an increment of 5. Notice the jump of 20 between March 19 and March 20.

These gaps serve a practical purpose. In the event that there are two or more individuals born on the same month and date and with names so similar that the

TABLE 6. Minnesota, Michigan, Maryland code for first and middle names beginning with *Al*.

		Al	039		
Ala	040	*Alj*	049	*Als*	058
Alb	041	*Alk*	050	*Alt*	059
Alc	042	*All*	051	*Alu*	060
Ald	043	*Alm*	052	*Alv*	061
Ale	044	*Aln*	053	*Alw*	062
Alf	045	*Alo*	054	*Alx*	063
Alg	046	*Alp*	055	*Aly*	064
Alh	047	*Alq*	056	*Alz*	065
Ali	048	*Alr*	057		

TABLE 7. Minnesota, Michigan, Maryland code for dates in March.

	March - 158	
1 - 159	11 - 187	21 - 229
2 - 162	12 - 189	22 - 232
3 - 164	13 - 192	23 - 234
4 - 167	14 - 194	24 - 237
5 - 169	15 - 197	25 - 239
6 - 172	16 - 199	26 - 242
7 - 174	17 - 202	27 - 244
8 - 177	18 - 204	28 - 247
9 - 182	19 - 207	29 - 249
10 - 184	20 - 227	30 - 252
		31 - 254

hashing function does not distinguish between them (e.g., Jill Paula Smith and Jimmy Paul Smythe), the first person who applies for a license is assigned the number given by the algorithm while the second person is assigned the next higher number thereby using one of the numbers in the gap for birthdays. For example, if Jill Paula Smith is born on March 2 and is the first to receive the combination S530-441-675-162 as determined by the algorithm, then the next person who yields the same number is assigned S530-441-675-163 instead. Once all of the higher numbers in a gap have been assigned, lower numbers are used. Thus the third applicant with a name yielding the combination S530-441-675 born on March 2 would be assigned the last three digits 161. As of 1984, this scheme had not yielded any duplications among 4,468,080 people in Maryland while of Michigan's 6,332,878 drivers by 1987 there are 56 that have a number not uniquely their own. In fact, Michigan has two numbers that are each shared by four individuals and three that are each shared by three individuals. A common cause of duplication is the custom of naming a son after the father. When both share the same birthday a duplication occurs.

Summary

TABLE 8 summarizes the information the author has discovered about the coding of driver's license numbers. Unfortunately our knowledge is incomplete. Several states (e.g., Florida, New York, Minnesota, Missouri, Wisconsin) keep their methods confidential. In some of these cases we were able to determine the coding scheme by examining data. A question mark after the letter *X* indicates the corresponding item is used in the coding, but we do not know the method involved. The expression (A) after an *X* indicates that the corresponding item is part of a scheme that is an alternative to the social security number.

E 6. Minnesota, Michigan, Maryland code for first and middle names
nning with *Al*.

		Al	039		
la	040	*Alj*	049	*Als*	058
lb	041	*Alk*	050	*Alt*	059
lc	042	*All*	051	*Alu*	060
ld	043	*Alm*	052	*Alv*	061
le	044	*Aln*	053	*Alw*	062
lf	045	*Alo*	054	*Alx*	063
lg	046	*Alp*	055	*Aly*	064
lh	047	*Alq*	056	*Alz*	065
li	048	*Alr*	057		

TABLE 7. Minnesota, Michigan. Maryland code for dates in March.

	March - 158	
1 - 159	11 - 187	21 - 229
2 - 162	12 - 189	22 - 232
3 - 164	13 - 192	23 - 234
4 - 167	14 - 194	24 - 237
5 - 169	15 - 197	25 - 239
6 - 172	16 - 199	26 - 242
7 - 174	17 - 202	27 - 244
8 - 177	18 - 204	28 - 247
9 - 182	19 - 207	29 - 249
10 - 184	20 - 227	30 - 252
		31 - 254

nction does not distinguish between them (e.g., Jill Paula Smith and Jimmy the), the first person who applies for a license is assigned the number given orithm while the second person is assigned the next higher number thereby of the numbers in the gap for birthdays. For example, if Jill Paula Smith is March 2 and is the first to receive the combination S530-441-675-162 as d by the algorithm, then the next person who yields the same number is S530-441-675-163 instead. Once all of the higher numbers in a gap have gned, lower numbers are used. Thus the third applicant with a name he combination S530-441-675 born on March 2 would be assigned the last its 161. As of 1984, this scheme had not yielded any duplications among people in Maryland while of Michigan's 6,332,878 drivers by 1987 there are ave a number not uniquely their own. In fact, Michigan has two numbers each shared by four individuals and three that are each shared by three s. A common cause of duplication is the custom of naming a son after the hen both share the same birthday a duplication occurs.

y

ummarizes the information the author has discovered about the coding of cense numbers. Unfortunately our knowledge is incomplete. Several states ida, New York, Minnesota, Missouri, Wisconsin) keep their methods confi- 1 some of these cases we were able to determine the coding scheme by ; data. A question mark after the letter *X* indicates the corresponding item the coding, but we do not know the method involved. The expression (*A*) *X* indicates that the corresponding item is part of a scheme that is an to the social security number.

TABLE 8. Summary of Schemes for Assigning Driver's License Numbers.

State	*Social Security Number*	*Computer or Sequential Number*	*Check Digit*	*Last Name Coded*	*First Name Coded*	*Middle Name Coded*	*Year of Birth Coded*	*Month of Birth Coded*	*Day of Birth Coded*	*Sex Coded*
Alabama		X								
Alaska		X								
Arizona	X									
Arkansas	X	X(A)								
California		X								
Colorado		X								
Connecticut		X						X		
Delaware		X					X			
Florida				X	X	X	X	X	X	X
Georgia	X	X(A)								
Hawaii	X									
Idaho	X	X(A)								
Illinois				X	X	X	X	X	X	X
Indiana	X	X(A)								
Iowa	X									
Kansas		X								
Kentucky	X									
Louisiana		X								
Maine		X		X	X		X	X	X	
Maryland				X	X	X		X	X	
Massachusetts	X									
Michigan				X	X	X		X	X	
Minnesota				X	X	X		X	X	
Mississippi	X									

TABLE 8.

State	*Social Security Number*	*Computer Sequential Number*	*Check Digit*	*Last Name Coded*	*First Name Coded*	*Middle Name Coded*	*Year of Birth Coded*	*Month of Birth Coded*	*Day of Birth Coded*	*Sex Coded*
Missouri				X(?)	X(?)	X(?)		X	X	X
Montana	X				X (A)		X (A)	X (A)	X (A)	X (A)
Nebraska		X								
Nevada	X	X(A)								
New Hampshire				X	X		X	X	X	
New Jersey				X	X	X	X	X		X
New Mexico		X	X mod 11							
New York				X(?)	X(?)	X(?)	X	X(?)	X(?)	?
North Carolina		X								
North Dakota	X	X(A)								
Ohio		X								
Oklahoma	X	X(A)								
Oregon		X								
Pennsylvania		X								
Rhode Island		X								
South Carolina		X								
South Dakota		X	X mod 10				X	X		
Tennessee		X	X mod 11							
Texas		X								
Utah		X	X mod 10							
Vermont		X	X mod 11							
Virginia	X	X(A)								
Washington			X mod 10	X	X	X	X	X	X	
West Virginia		X								
Wisconsin			X(?)	X	X	X		X	X	X
Wyoming		X	X(?)							

REFERENCES

1. Steve Connor, The invisible border guard, *New Scientist* Jan. 5 (1984), 9–14.
2. Joseph A. Gallian, The zip code bar code, *The UMAP Journal* 7 (1986), 191–194.
3. Joseph A. Gallian and Steven Winters, Modular arithmetic in the marketplace, *Amer. Math. Monthly* 95 (1988), 548–551.
4. H. Peter Gumm, A new class of check digit methods for arbitrary number systems, *IEEE Transactions on Information Theory* 31 (1985), 102–105.
5. Donald E. Knuth, *The Art of Computer Programming*, Vol. 3, Addison-Wesley, Reading, MA, 1973.
6. Philip M. Tuchinsky, International standard book numbers, *The UMAP Journal* 5 (1985), 41–54.
7. J. Verhoeff, *Error Detecting Decimal Codes*, Mathematical Centrum, Amsterdam, 1969.
8. E. F. Wood, Self-checking codes–an application of modular arithmetic, *Mathematics Teacher* 80 (1987), 312–316.

Assigning Driver's License Numbers

JOSEPH A. GALLIAN
University of Minnesota
Duluth, MN 55812

"You know my name
look up the number"

John Lennon and Paul McCartney, *You know my name*,
single, B-side of *Let it be*, March 1970.

Introduction

Among the individual states, a wide variety of methods are used to assign driver's license numbers. The three most common methods, a sequential number, the social security number, and a computer-generated number, are uninteresting mathematically. On the other hand, many states encode data such as month and date of birth, year of birth, and sex in ways that involve elementary mathematics. Seven states go so far as to employ a check digit for possible detection of forgery or errors. Several states assign driver's license numbers by applying complicated hashing functions to the first, middle, and last names and formulas or tables for the month and date of birth. Surprisingly, the assignment of numbers is not always injective. In Michigan, for instance, there are 56 numbers whose inverse image has two or more members. New Jersey incorporates eye color into the number. Some states keep their method confidential. In a few instances, administrators of the license bureaus do not know the method used to assign numbers in their state! In this paper we discuss some of the methods we have uncovered.

Check Digit Schemes in General Use

Schemes for the assignment of identification numbers are extremely varied in methodology and in the information encoded. Most interesting to mathematicians are those that incorporate an extra digit for the detection of errors or fraud. Although the purpose of this paper is to analyze the methods used for driver's license numbers, it is worthwhile to begin with a brief survey of the methods employed to assign check digits to the most ubiquitous numbers in use and to provide a theoretical result that delineates their limitations.

The simplest and least effective method for assigning a check digit is to use the remainder or inverse of the remainder of the identification number modulo some number. For airline tickets, UPS packages, and Federal Express mail the check digit is the identification number modulo 7. At the bottom of FIGURE 1 we see the airline ticket number 17000459570 (the airline code 012 is not used in the calculation) is assigned a check digit 3 since $17000459570 \equiv 3 \bmod 7$.

U.S. postal money orders use the remainder modulo 9 while VISA traveler's checks use the inverse of the number modulo 9. Thus, the check digit for the VISA number 1002044679091 is 2 since $1002044679091 \equiv 7 \bmod 9$.

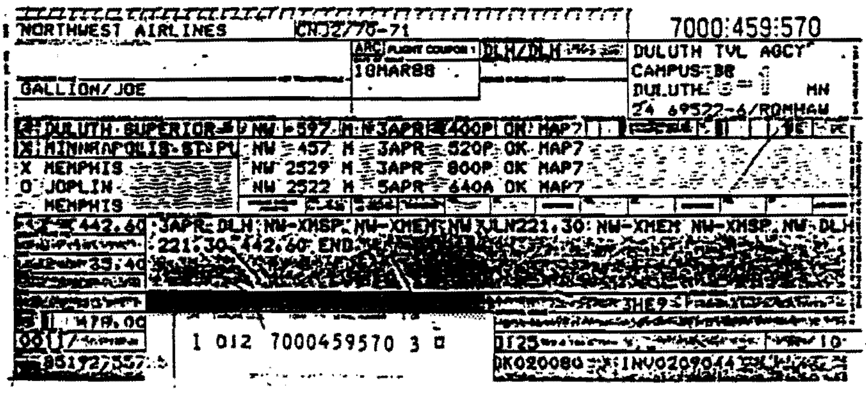

FIGURE 1
Airline ticket with number 17000459570 and check digit 3.

The modulo 7 schemes detect all errors involving a single digit except those where b is substituted for a and $|a-b| = 7$. Likewise, an error of the sort $\cdots a_i \cdots a_j \cdots \to \cdots a_j \cdots a_i \cdots$ will go undetected if $|a_i - a_j| = 7$ or if 6 divides $j-i$.

The modulo 9 schemes are slightly better at detecting single-digit errors: Only a substitution of a 9 for a 0 or vice versa goes undetected. On the other hand, the only errors of the form $\cdots a_i \cdots a_j \cdots \to \cdots a_j \cdots a_i \cdots$ that are undetected are those involving the check digit itself. (A quick proof of this is to observe that the residue of a number modulo 9 is the residue of the sum of its digits modulo 9.)

Nearly all methods for assigning a check digit to a string of digits involve a scalar product of two vectors and modular arithmetic. For a string $a_1 a_2 \cdots a_{k-1}$ and a modulus n, many schemes assign a check digit a_k so that

$$(a_1, a_2, \ldots, a_k) \cdot (w_1, w_2, \ldots, w_k) \equiv 0 \bmod n.$$

We call such schemes *linear* and we call the vector $(w_1, w_2, \ldots, w_k)$ the *weighting vector*. The Universal Product Code (UPC) used on grocery items employs the weighting vector $(3,1,3,1,3,1,3,1,3,1,3,1)$ with $n = 10$; the International Standard Book Number (ISBN) utilizes $(10,9,8,7,6,5,4,3,2,1)$ and $n = 11$; banks in the U.S. use $(7,3,9,7,3,9,7,3,9)$ with $n = 10$; many Western countries use $(7,3,1,7,3,1,\ldots)$ with $n = 10$ to assign check digits to numbers on passports. Notice that the division schemes mentioned at the outset of this section are also linear with weighting vectors of the form $(10^{k-2}, 10^{k-3}, \ldots, 10^0, \pm 1)$.

The error-detecting capability of linear schemes is given by the following theorem.

THEOREM. *Suppose a number* $a_1 a_2 \cdots a_k$ *satisfies the condition* $(a_1, a_2, \ldots, a_k) \cdot (w_1, w_2, \ldots, w_k) \equiv 0 \bmod n$. *Then the single error occasioned by substituting* a_i' *for* a_i *is undetectable if and only if* $(a_i' - a_i)w_i$ *is divisible by* n *and a sole error of the form* $\cdots a_i \cdots a_j \cdots \to \cdots a_j \cdots a_i \cdots$ *is undetectable if and only if* $(a_i - a_j)(w_i - w_j)$ *is divisible by* n.

Proof. If a_i' is substituted for a_i, then the dot product of the correct number and the incorrect number differ by $(a_i' - a_i)w_i$. Thus, the error is undetected if and only if $(a_i' - a_i)w_i \equiv 0 \bmod n$.

Now consider an error of the form $\cdots a_i \cdots a_j \cdots \to \cdots a_j \cdots a_i \cdots$. Here the dot product of the correct number and the incorrect number differ by

$$(a_i w_i + a_j w_j) - (a_j w_i + a_i w_j) = (a_i - a_j)(w_i - w_j)$$

The conclusion now follows as before.

Since the most common moduli are 10 and 11, the following corollary is worth mention.

COROLLARY. *Suppose an identification number* $a_1 a_2 \cdots a_k$ *satisfies*

$$(a_1, a_2, \dots, a_k) \cdot (w_1, w_2, \dots, w_k) \equiv 0 \bmod n$$

where $0 \leqslant a_i < n$ *for each* i. *Then all single-digit errors occurring in the ith position are detectable if and only if* w_i *is relatively prime to* n *and all errors of the form* $\cdots a_i \cdots a_j \cdots \to \cdots a_j \cdots a_i \cdots$ *are detectable if and only if* $w_i - w_j$ *is relatively prime to* n.

The above theorem verifies our claims about the error-detection capability of the schemes used on money orders and airline tickets. It also explains why the bank and passport schemes will detect some errors of the form $\cdots abc \cdots \to \cdots cba \cdots$ while the UPC code will detect no such errors. Observe that because 11 is prime the ISBN code detects 100% of all single-digit errors and 100% of all errors involving the interchange of two digits. But there is a price to pay for using the modulus 11: The number a_k needed to satisfy the condition may be 10, which is two digits. In this case, an alphabetic character such as X or A is used or such numbers are not issued. As we will see below there are schemes that use the modulus 11 that do not resort to an alphabetic character, but there is a price to pay for this too: Not all transposition errors are detectable. More information about check digits schemes in use can be found in [1], [2], [3], [4], [6], [7], [8].

Check Digits on Driver's License Numbers

The state of Utah assigns an eight-digit driver's license number in sequential order, say $a_1 a_2 \cdots a_8$, then appends a check digit a_9 using a linear scheme with weighting vector $(9, 8, 7, 6, 5, 4, 3, 2, 1)$ and modulus 10. This method is identical to that used by the American Chemical Society for its chemical registry numbers. Assuming that all errors are equally likely,[1] this method detects $73/81$ or 90.1% of all single-digit errors and 100% of all transposition errors (i.e., errors of the form $\cdots ab \cdots \to \cdots ba \cdots$).[2]

To verify the single-error detection rate, observe from our theorem that in positions 2, 4, 6, and 8 substitution of b for a will go undetected when $|a - b| = 5$; in position 5, a substitution of b for a will go undetected when a and b have the same parity. Thus in each of positions 2, 4, 6, and 8 there are 10 undetected errors among 90 possible errors while in the fifth position, 40 of the 90 possible errors are undetected.

[1] In practice all errors are not equally likely. One study [7, p. 15] revealed that a substitution of a "5" for a "3" was 17 times as likely as a substitution of a "9" for a "1." However, available data are insufficient to assign reliable probabilities to the various error possibilities.

[2] A highly publicized error of this kind recently occurred when Lt. Col. Oliver North gave U.S. Assistant Secretary of State Elliot Abrams an incorrect Swiss bank account number for depositing $10 million for the contras. The correct number begins with "386"; the number North gave to Abrams begins with "368."

So, in all, 80 of 810 errors are undetected.

Someone working for the Canadian province of Quebec, probably having seen a scheme like the one used by Utah somewhere, came up with the laughable weighting vector $(12, 11, 10, 9, \ldots, 2, 1)$ with modulus 10 to assign a check digit. Of course, any error in the third position is undetectable and weights of 12 and 11 have the same effect as the weights 2 and 1.

Newfoundland uses the weighting vector $(1, 2, 3, 4, 5, 6, 7, 8, 1)$ with modulus 10. This is nearly identical to the Utah scheme except that it will not detect the event that the first and last digit are interchanged.

Three states use a modified linear scheme with modulus 11. New Mexico and Tennessee append a check digit a_8 to $a_1 a_2 \cdots a_7$ as follows: First calculate

$$x = -(a_1, a_2, \ldots, a_7) \cdot (2, 7, 6, 5, 4, 3, 2) \bmod 11.$$

If $x = 0$, a_8 is 1; if $x = 10$, $a_8 = 0$; otherwise $a_8 = x$. This method catches 100% of all single-digit errors. Furthermore, the only errors of the form $\cdots a_i \cdots a_j \cdots \to \cdots a_j \cdots a_i \cdots$ that go undetected are those where $i = 1$ and $j = 7$ (an unlikely error indeed) and some involving the check digits 0 and 1. Assuming that all transposition errors are equally likely,[3] this method detects 98.2% of such errors. The Vermont scheme is the same as the one used by New Mexico except that when $x = 0$, the letter "A" is the check. This method, like the ISBN method, yields a 100% detection rate for both single-digit and transposition errors, but utilizes two formats for numbers. Notice that there would be nothing lost if the weighting vector began with 8 instead of 2 and there would be a slight gain since errors of the form $a_1 a_2 \cdots a_7 a_8 \to a_7 a_2 \cdots a_1 a_8$ would be detectable.

The state of Washington and the province of Manitoba use a check digit scheme devised by IBM in 1964 to assign a check digit. The license number is a blend of 12 alphabetic and numeric characters. To compute the Washington check digit, alphabetic characters are assigned numeric values as follows: $* \to \emptyset$, $A \to 1$, $B \to 2, \ldots, I \to 9$, $J \to 1$, $K \to 2, \ldots, R \to 9$, $S \to 2$, $T \to 3, \ldots, Z \to 9$. (Notice the aberration at S.) The 12-character license number, after an alphabetic to numeric conversion, then corresponds to a string of digits $a_1 a_2 \cdots a_{12}$ with a_{10} as the check digit calculated as $|a_1 - a_2 + a_3 - a_4 + \cdots + a_9 - a_{11} + a_{12}| (\bmod 10)$. Interestingly, the use of the absolute value actually makes the method nonlinear and reduces the error detection capability of the scheme. It would have been better to use the linear scheme with weighting vector $(1, 9, 1, 9, \ldots, 1) \bmod 10$.

South Dakota and Saskatchewan employ another nonlinear scheme developed by IBM to assign its check digit. In South Dakota, a six-digit computer-generated string is assigned a check digit as follows. Each of the second, fourth, and sixth digits is multiplied by 2 and the digits of the resulting products are summed (e.g., a 7 yields $1 + 4 = 5$ while a 3 yields 6). This resulting total is then added to the digits in the first, third, and fifth positions. The check digit is the inverse modulo 10 of this tally. (Alternatively, the check digit is $(10 - ((\Sigma_{i\text{ even}}\ (2a_i + \lfloor 2a_i/10 \rfloor) + \Sigma_{i\text{ odd}}\ a_i) (\bmod 10))) \bmod 10$.) Thus, the check digit for 263743 is $-(1 + 2 + 1 + 4 + 6 + 2 + 3 + 4) \bmod 10 = 7$. This method is used by credit card companies, many libraries, and drug stores in the U.S. and by banks in West Germany, although in some instances it is the digits in the odd positions that are multiplied by 2. It detects 100% of all

[3] In reality, the likelihood of a transposition error depends on the pair of digits as well as the positions. But as before, reliable data for these occurrences are unavailable.

single-digit errors and 97.8% of transposition errors. To see that all single-digit errors are detected, observe that distinct digits contribute distinct values to the sum. To compute the detection rate for errors of the form $\cdots ab \cdots \to \cdots ba \cdots$, suppose such an error is undetected. We consider four cases. For simplicity, assume a in the correct number is in position 2, 4 or 6. The alternative case gives the same result.

Case 1. $a, b < 5$
Then $2a + b \equiv 2b + a \bmod 10$.
Thus $a - b = 0$ and $a = b$.

Case 2. $a < 5$, $b \geqslant 5$
Then $2a + b \equiv 2b - 9 + a \bmod 10$.
It follows that $b - a = 9$ so that $b = 9$ and $a = 0$.

Case 3. $a \geqslant 5$, $b < 5$
Then $2a - 9 + b \equiv 2b + a \bmod 10$.
So, $a - b = 9$ and $a = 9$ and $b = 0$.

Case 4. $a \geqslant 5$, $b \geqslant 5$
Then $2a - 9 + b \equiv 2b - 9 + a \bmod 10$.
Thus $a - b = 0$ and $a = b$.

So all transposition errors except $09 \leftrightarrow 90$ are detected. Since there are 90 possible transposition errors, the error detection rate is $88/90$ or 97.8%.

It is worth noting that Gumm [4] has shown that it is not possible to improve upon these rates with any system that uses addition modulo 10 to compute the check digit without utilizing an extra character, as was the case for the New Mexico scheme.

Wisconsin appends a check digit to a 13-digit string. Unfortunately, I have not been able to figure out how this scheme works. I know it isn't linear; for if so, the weighting vector $(w_1, w_2, \ldots, w_{13}, w_{14})$ could be determined by gathering up a large number of valid license numbers to produce a system of linear equations with the w_i's as the unknowns. I have done this for modulo 10 and 11 to no avail. To circumvent any peculiarity that might arise involving a check digit of 10 in a modulo 11 scheme (e.g., New Mexico), I avoided numbers with a check digit of 0 or 1.

Encoding Personal Data

Here is the driver's license number of a Wisconsin resident: E 425-7276-9176-07. What information about the holder can you deduce from this number: year of birth, day and month of birth, sex, name? None of these is obvious. Let's go the other direction. I am a resident of Minnesota. I was born on January 5, 1942, and my middle name is Anthony. From this can you deduce my driver's license number?

Eleven states assign their driver's license numbers with hashing functions applied solely to personal data. A good hash function should be fast and minimize collisions (see [5, pp. 506–544] for a detailed discussion of this topic). Of course, there will be occasions when two or more individuals have enough personal data in common that collisions will occur. Most states have a tie-breaking mechanism to handle this situation. Coding license numbers only from personal data enables automobile insurers, government entities, and law enforcement agencies to determine the numbers when necessary.

Washington uses a complicated blend of name, check digit, and codes for the month and date of birth to assign its numbers. This 12-digit identifier consists of the first five letters of the surname; the first and middle initials (* is used when a name has less than five characters, or there is no middle initial); the year of birth subtracted from 100 (we suspect this is done to disguise the year of birth); a check digit; a code for the month of birth; and a code for the day of birth. For instance, Fielding Mellish (no middle name) born on 10/29/42 receives the identifier MELLI F* 587P9. When checked against a file of 1.6 million items, this scheme yielded duplicates at the rate of 0.03% and only one number appeared as many as four times. (Most of the duplications represented twins.) To ensure that the correspondence between individuals and numbers is injective, 17 alternate codes for month and year of birth are available. For example, an S can be used instead of a B for January or a Z instead of a 9 for the year of birth. Interestingly, the check digit is invariant under all alternate coding. The primary code and one alternate for months is given in TABLE 1 and the code for the days is given in TABLE 2. Notice the absence of completely predictable patterns.

TABLE 1. Washington code for months.

Months	Codes	Alternate Codes
January	B	S
February	C	T
March	D	U
April	J	1
May	K	2
June	L	3
July	M	4
August	N	5
September	O	6
October	P	7
November	Q	8
December	R	9

TABLE 2. Washington code for days.

1 - A	7 - G	13 - L	19 - R	25 - 5	31 - U
2 - B	8 - H	14 - M	20 - 0	26 - 6	
3 - C	9 - Z	15 - N	21 - 1	27 - 7	
4 - D	10 - S	16 - W	22 - 2	28 - 8	
5 - E	11 - J	17 - P	23 - 3	29 - 9	
6 - F	12 - K	18 - Q	24 - 4	30 - T	

Illinois, Florida, and Wisconsin encode the surname, first name, middle initial, date of birth, and sex by a quite sophisticated scheme. The first character of the license number is the first character of the name. The next three characters are obtained by applying the "Soundex Coding System" to the surname as follows:

1. Delete all occurrences of h and w.
2. Assign numbers to the remaining letters as follows:
   $b, f, p, v \to 1$ $\quad$ $l \to 4$
   $c, g, j, k, q, s, x, z \to 2$ $\quad$ $m, n \to 5$
   $d, t \to 3$ $\quad$ $r \to 6$
   (No values are assigned to a, e, i, o, u, and y.)
3. If two or more letters with the same numeric value are adjacent, omit all but the first. (Here a, e, i, o, u, and y act as separators.) For example, Schworer becomes Sorer and Hughgill becomes Ugil.

4. Delete the first character of the original name if still present.
5. Delete all occurrences of a, e, i, o, u, and y.
6. Use the first three digits corresponding to the remaining letters; append trailing zeros if less than three letters remain.

Here are some examples: Schworer → S-660; Hughgill → H-240; Skow → S-000; Sachs → S-200; Lennon → L-550; McCartney → M-263.

We parenthetically remark that the Soundex System was designed so that likely misspellings of a name would nevertheless result in the correct coding of the name. For example, frequent misspellings of my name are: Gallion, Gillian, Galian, Galion, Gilliam, Gallahan, and Galliam. Observe that all of these yield the same coding as Gallian. We also mention that the above method differs somewhat from the system called Soundex by Knuth in [5, p. 392].

The next three digits are determined by summing numbers that correspond to the first name and middle initial. The scheme for doing this begins with the block 000 for the letter A and makes jumps of 20 for especially common names and each subsequent letter of the alphabet. A small portion of this scheme is given in TABLE 3. The values assigned to the middle initial are given in TABLE 4.

So Aaron G. Schlecker would be coded as S426-007 (S426 from Schlecker; 000 for Aaron +7 for "G"), while Anne P. Schlecker would be coded as S426-055.

The last five digits of Illinois and Florida numbers capture the year and date of birth as well as the sex. In Illinois, each day of the year is assigned a three-digit number in sequence beginning with 001 for January 1. However, each month is assumed to have 31 days. Thus, March 1 is given 063. These numbers are then used to identify the month and day of birth of male drivers. For females, the scheme is identical except January 1 begins with 601. The last two digits of the year of birth, separated by a dash (probably for camouflage), are listed in the 5th and 4th positions from the end of the driver's license number. Thus, a male born on July 18, 1942, would have the last five digits 4-2204 while a female born on the same day would have 4-2804. When necessary, Illinois adds an extra character to avoid duplications.

TABLE 3. Illinois, Florida, Wisconsin given name or first initial code.

000	–	A
020	–	Albert, Alice
040	–	Ann, Anna, Anne, Annie, Arthur
060	–	B
080	–	Bernard, Bette, Bettie, Betty
100	–	C

TABLE 4. Illinois, Florida, Wisconsin middle initial code.

0 - none	10 - J
1 - A	11 - K
2 - B	12 - L
3 - C	13 - M
4 - D	14 - N, O
5 - E	15 - P, Q
6 - F	16 - R
7 - G	17 - S
8 - H	18 - T, U, V
9 - I	19 - W, X, Y, Z

Among the 9,397,518 licenses on file on January 1, 1987, this occurred in 14,856 instances. Of these, 55 numbers corresponded to three individuals (excluding the extra digit). No number corresponded to more than three people.

The scheme to identify birthdate and sex in Florida is the same as Illinois except each month is assumed to have 40 days and 500 is added for women. For example, the five digits 49583 belong to a woman born on March 3, 1949.

Wisconsin employs the same scheme as Florida to generate the first 12 of their 14 characters. The thirteenth character is an integer issued sequentially beginning with 0 to people who share the same first 12 characters. The fourteenth character is a check digit.

A Missouri driver's license number has 16 characters. The first 13 characters are obtained by applying a hashing function to the first five letters of the surname, the first three letters of the first name and the middle initial. (The method of encoding is similar to that used by Florida.) The final three characters are a function of the month and day of birth and sex. For a male born in month m and day d the three digits are $63m + 2d$. For a female, the corresponding formula is $63m + 2d + 1$. Thus the number of a woman born on March 4 has the final three characters 198. To avoid duplications, Missouri assigns a 17th character. Among the first 3,921,922 numbers issued, 31,719 have a 17th character.

Last, we discuss the scheme employed by Minnesota, Michigan, and Maryland. The number is a function of last name, first name, middle name, month and date of birth. The first four characters are determined by the Soundex System, as was the case for Illinois, Florida, and Wisconsin. The first and middle names account for the next six characters and the same algorithm is applied to both names. In the majority of cases the first two characters of the name determine the desired three digits for each name (see TABLE 5 for a sample); for common pairs of leading letters such as Al or Ja, the third letter is invoked (see TABLE 6); 11 three-digit numbers are uniquely assigned to the 11 most popular names (e.g., 189 ↔ Edward; 210 ↔ Elizabeth).

TABLE 5. Minnesota, Michigan, Maryland code for first and middle names beginning with A except Al.

		A	027		
Aa	028	Aj	037	As	072
Ab	029	Ak	038	At	073
Ac	030	Al	—	Au	074
Ad	031	Am	066	Av	075
Ae	032	An	067	Aw	076
Af	033	Ao	068	Ax	077
Ag	034	Ap	069	Ay	078
Ah	035	Aq	070	Az	079
Ai	036	Ar	071		

The final three digits are based on month and date of birth (but not year). Each day of the year is assigned a three-digit number in a monotonically increasing fashion. Although the usual pattern is to alternate increments of 3 and 2, there are numerous seemingly random increments at unpredictable dates. The month of March illustrates this behavior well. Notice from TABLE 7 that March 1 is assigned 159. Subsequent days are assigned values by increments of 3 and 2 in alternating fashion until March 8. Then there is an increment of 5. Notice the jump of 20 between March 19 and March 20.

These gaps serve a practical purpose. In the event that there are two or more individuals born on the same month and date and with names so similar that the

TABLE 6. Minnesota, Michigan, Maryland code for first and middle names beginning with *Al*.

		Al	039		
Ala	040	*Alj*	049	*Als*	058
Alb	041	*Alk*	050	*Alt*	059
Alc	042	*All*	051	*Alu*	060
Ald	043	*Alm*	052	*Alv*	061
Ale	044	*Aln*	053	*Alw*	062
Alf	045	*Alo*	054	*Alx*	063
Alg	046	*Alp*	055	*Aly*	064
Alh	047	*Alq*	056	*Alz*	065
Ali	048	*Alr*	057		

TABLE 7. Minnesota, Michigan, Maryland code for dates in March.

	March - 158	
1 - 159	11 - 187	21 - 229
2 - 162	12 - 189	22 - 232
3 - 164	13 - 192	23 - 234
4 - 167	14 - 194	24 - 237
5 - 169	15 - 197	25 - 239
6 - 172	16 - 199	26 - 242
7 - 174	17 - 202	27 - 244
8 - 177	18 - 204	28 - 247
9 - 182	19 - 207	29 - 249
10 - 184	20 - 227	30 - 252
		31 - 254

hashing function does not distinguish between them (e.g., Jill Paula Smith and Jimmy Paul Smythe), the first person who applies for a license is assigned the number given by the algorithm while the second person is assigned the next higher number thereby using one of the numbers in the gap for birthdays. For example, if Jill Paula Smith is born on March 2 and is the first to receive the combination S530-441-675-162 as determined by the algorithm, then the next person who yields the same number is assigned S530-441-675-163 instead. Once all of the higher numbers in a gap have been assigned, lower numbers are used. Thus the third applicant with a name yielding the combination S530-441-675 born on March 2 would be assigned the last three digits 161. As of 1984, this scheme had not yielded any duplications among 4,468,080 people in Maryland while of Michigan's 6,332,878 drivers by 1987 there are 56 that have a number not uniquely their own. In fact, Michigan has two numbers that are each shared by four individuals and three that are each shared by three individuals. A common cause of duplication is the custom of naming a son after the father. When both share the same birthday a duplication occurs.

Summary

TABLE 8 summarizes the information the author has discovered about the coding of driver's license numbers. Unfortunately our knowledge is incomplete. Several states (e.g., Florida, New York, Minnesota, Missouri, Wisconsin) keep their methods confidential. In some of these cases we were able to determine the coding scheme by examining data. A question mark after the letter *X* indicates the corresponding item is used in the coding, but we do not know the method involved. The expression (*A*) after an *X* indicates that the corresponding item is part of a scheme that is an alternative to the social security number.

.E 6. Minnesota, Michigan, Maryland code for first and middle names
nning with *Al*.

		Al	039		
la	040	*Alj*	049	*Als*	058
lb	041	*Alk*	050	*Alt*	059
lc	042	*All*	051	*Alu*	060
ld	043	*Alm*	052	*Alv*	061
le	044	*Aln*	053	*Alw*	062
lf	045	*Alo*	054	*Alx*	063
lg	046	*Alp*	055	*Aly*	064
lh	047	*Alq*	056	*Alz*	065
li	048	*Alr*	057		

TABLE 7. Minnesota, Michigan. Maryland code for dates in March.

	March - 158	
1 - 159	11 - 187	21 - 229
2 - 162	12 - 189	22 - 232
3 - 164	13 - 192	23 - 234
4 - 167	14 - 194	24 - 237
5 - 169	15 - 197	25 - 239
6 - 172	16 - 199	26 - 242
7 - 174	17 - 202	27 - 244
8 - 177	18 - 204	28 - 247
9 - 182	19 - 207	29 - 249
10 - 184	20 - 227	30 - 252
		31 - 254

nction does not distinguish between them (e.g., Jill Paula Smith and Jimmy the), the first person who applies for a license is assigned the number given gorithm while the second person is assigned the next higher number thereby of the numbers in the gap for birthdays. For example, if Jill Paula Smith is March 2 and is the first to receive the combination S530-441-675-162 as ed by the algorithm, then the next person who yields the same number is S530-441-675-163 instead. Once all of the higher numbers in a gap have gned, lower numbers are used. Thus the third applicant with a name he combination S530-441-675 born on March 2 would be assigned the last its 161. As of 1984, this scheme had not yielded any duplications among people in Maryland while of Michigan's 6,332,878 drivers by 1987 there are ave a number not uniquely their own. In fact, Michigan has two numbers each shared by four individuals and three that are each shared by three s. A common cause of duplication is the custom of naming a son after the hen both share the same birthday a duplication occurs.

Y

ummarizes the information the author has discovered about the coding of cense numbers. Unfortunately our knowledge is incomplete. Several states ida, New York, Minnesota, Missouri, Wisconsin) keep their methods confi- n some of these cases we were able to determine the coding scheme by ; data. A question mark after the letter *X* indicates the corresponding item the coding, but we do not know the method involved. The expression (*A*) *X* indicates that the corresponding item is part of a scheme that is an to the social security number.

TABLE 8. Summary of Schemes for Assigning Driver's License Numbers.

State	*Social Security Number*	*Computer or Sequential Number*	*Check Digit*	*Last Name Coded*	*First Name Coded*	*Middle Name Coded*	*Year of Birth Coded*	*Month of Birth Coded*	*Day of Birth Coded*	*Sex Coded*
Alabama		X								
Alaska		X								
Arizona	X									
Arkansas	X	X(A)								
California		X								
Colorado		X								
Connecticut		X						X		
Delaware		X					X			
Florida				X	X	X	X	X	X	X
Georgia	X	X(A)								
Hawaii	X									
Idaho	X	X(A)								
Illinois				X	X	X	X	X	X	X
Indiana	X	X(A)								
Iowa	X									
Kansas		X								
Kentucky	X									
Louisiana		X								
Maine		X		X	X		X	X	X	
Maryland				X	X	X		X	X	
Massachusetts	X									
Michigan				X	X	X		X	X	
Minnesota				X	X	X		X	X	
Mississippi	X									

TABLE 8.

State	*Social Security Number*	*Computer Sequential Number*	*Check Digit*	*Last Name Coded*	*First Name Coded*	*Middle Name Coded*	*Year of Birth Coded*	*Month of Birth Coded*	*Day of Birth Coded*	*Sex Coded*
Missouri				X(?)	X(?)	X(?)		X	X	X
Montana	X				X (A)		X (A)	X (A)	X (A)	X (A)
Nebraska		X								
Nevada	X	X(A)								
New Hampshire				X	X		X	X	X	
New Jersey				X	X	X	X	X		X
New Mexico		X	X mod 11							
New York				X(?)	X(?)	X(?)	X	X(?)	X(?)	?
North Carolina		X								
North Dakota	X	X (A)								
Ohio		X								
Oklahoma	X	X(A)								
Oregon		X								
Pennsylvania		X								
Rhode Island		X								
South Carolina		X								
South Dakota		X	X mod 10				X	X		
Tennessee		X	X mod 11							
Texas		X								
Utah		X	X mod 10							
Vermont		X	X mod 11							
Virginia	X	X(A)								
Washington			X mod 10	X	X	X	X	X	X	
West Virginia		X								
Wisconsin			X(?)	X	X	X		X	X	X
Wyoming		X	X(?)							

REFERENCES

1. Steve Connor, The invisible border guard, *New Scientist* Jan. 5 (1984), 9–14.
2. Joseph A. Gallian, The zip code bar code, *The UMAP Journal* 7 (1986), 191–194.
3. Joseph A. Gallian and Steven Winters, Modular arithmetic in the marketplace, *Amer. Math. Monthly* 95 (1988), 548–551.
4. H. Peter Gumm, A new class of check digit methods for arbitrary number systems, *IEEE Transactions on Information Theory* 31 (1985), 102–105.
5. Donald E. Knuth, *The Art of Computer Programming*, Vol. 3, Addison-Wesley, Reading, MA, 1973.
6. Philip M. Tuchinsky, International standard book numbers, *The UMAP Journal* 5 (1985), 41–54.
7. J. Verhoeff, *Error Detecting Decimal Codes*, Mathematical Centrum, Amsterdam, 1969.
8. E. F. Wood, Self-checking codes–an application of modular arithmetic, *Mathematics Teacher* 80 (1987), 312–316.